NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**RADIO INTEROPERABILITY:
ADDRESSING THE REAL REASONS WE DON'T
COMMUNICATE WELL DURING EMERGENCIES**

by

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March 2006

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13. ABSTRACT (maximum 200 words)

Concerns about inadequate radio communications at the scene of disasters predate 9/11, and have been a focal point of homeland security funding since 2001. Under the umbrella term "interoperability," grant funding is facilitating the recent deployment of equipment to allow field personnel to patch radio systems together, with the expectation of immediate improvement of emergency scene communications dysfunction.

This thesis argues that there are numerous causal factors for inadequate disaster communications. Communications impediments include insufficient radio infrastructure, behavioral reactions by people in stressful situations, intergovernmental relations, inadequate procedures and training, and general lethargy over the need to institute special operating policies differing from routine practices.

The sole reliance upon technological solutions, without proportionate training and practice greatly reduces the effectiveness of radio patching equipment. Quite opposite from the intended effect, patching equipment, in the hands of those only minimally acclimated to radio system architecture, is likely to trigger unintended consequences of chaotic system overload (by combining two or more busy channels) and sector vulnerability (by combining unsecured general public systems with previously isolated public safety systems).

Our goal is to provide a thought-provoking examination of the entire realm of emergency scene communications issues and practical recommendations beyond superficial technological solutions.

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RADIO INTEROPERABILITY: ADDRESSING THE REAL REASONS WE DON'T COMMUNICATE WELL DURING EMERGENCIES

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A number of people can rightfully share in the honor I feel in having studied at the Naval Postgraduate School. The support provided by those around me enabled any contribution to the body of work achieved, and is gratefully acknowledged.

The encouragement and buoyancy provided by my family—my wife Debbie, my daughter Stephany, parents, and brother and sister were key to all the preparation that preceded the final production of this research effort.

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A word is in order for the inspiration and support provided by the faculty of NPS. They were challenging yet flexible, rigorous but respectful of other duties, and above all, they began the critically important task of stretching and challenging tradition-bound public servants to see a new way. *Failure of imagination* is not an option.

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EXECUTIVE SUMMARY

America's first responders—police, fire, emergency medical and allied professionals are faced with the arduous task of protecting our communities. One of the most pressing issues emerging in the post-9/11 era is the need to improve emergency scene radio communications. This concern actually pre-dates the terrorist attacks on America in 2001, and has been a commonly-cited issue after nearly every disaster or incident of major significance. The call for action has quickened in pace during the first half of this decade, and is sure to continue as a major issue in homeland security circles for years to come.

The one word on people's lips to describe the concern is "interoperability." While it had been used in limited circles throughout the 1990s, interoperability has only gained widespread integration into the parlance of emergency planners and responders during the last few years. Interoperability has been misapplied as a catch-all phrase to describe a multitude of issues surrounding emergency scene communications. Over the last two years, interoperability has risen to the top of the priority list for agencies seeking homeland security grant funding. Interoperability projects have a better chance of successful funding, and conversely, projects not demonstrating an appropriate level of interoperability consideration will be rejected or significantly scored lower in the review process.[1] Meetings and seminars on interoperability fill-up quickly and there is an element of frenzy and scrambling for jurisdictions to address interoperability. Yet, with all that said, many people would be hard-pressed to come up with a definition for "interoperability" and of those who did, wide variance would likely be noted.

1 "…each urban area receiving FY05 UASI funds must develop a plan to achieve tactical interoperable communications across jurisdictions in the urban area and test the plan through the exercise activity required for the IED scenario. Each state that does not have a designated urban area(s) must use the same multi-jurisdictional metropolitan area or region designated to test the prevention and response plans…" Office of State and Local Government Coordination and Preparedness, Office of Domestic Preparedness, U.S. Department of Homeland Security. Fiscal Year 2005 Homeland Security Grant Program, Program Guidelines and Application Kit, 2004, 52.

Is it police officers being able to talk to firefighters at the same incident; local fire officials talking to neighboring fire agencies? Are we talking about federal agencies with radio connection to state and local officials? Is it at the scene, or command post, or Emergency Operations Center? Will it be provided for every responder, or command-to-command, only? Or does it address the wider issue of radio system coverage, frequency spectrum capacities, technology piece ergonomics, and alternate (non-voice) communications methods?

This thesis argues that there is a larger, unacknowledged and unaddressed human factors issue of needing new procedures involved in the communications process, and that we have misjudged the real issue as being purely technological. The result has been the expenditure of hundreds of millions of dollars, (with some estimates of all homeland security grants now topping $1.5 billion dollars), on communications patching equipment predicated on the assumption that emergency scene communication will instantly and automatically be improved once the equipment is bought and plugged-in.[2] The complexities of the communications process need greater examination and modification before any turnkey solution will bring meaningful result.

The reader is provided with communications improvement alternatives, which should be carefully weighed and tailored by first responder policy makers, while devising a policy best suited for their local jurisdiction. Operating practices and regional variations make it difficult and undesirable for the thousands of police and fire departments across the U.S. to operate exactly the same. Despite minor regional differences, the overriding need to cooperatively work together, in the spirit and intent of homeland security initiatives dictates the development of common practices and policies that will help first responders bridge these regional differences. One aspect of needed common practice and policies involves new procedures for use by first responders when using radio equipment designed to improve interoperability.

2 Paul Davidson, "Compatible radio systems would cost billions," *USA Today*, December 29, 2005.

I. INTRODUCTION

The public servants in our communities—America's firefighters, law enforcement officers, emergency medical personnel, and a host of allied professionals, provide the first-line of defense and protection to our communities in times of crisis—both small and large-scale. During the evolutionary path we have traveled in securing the American homeland after the attacks of September 11, 2001, one phrase has resonated: *All Disasters Are Local*.[3] Those four simple words acknowledge a complex reality, a powerful message on the awesome responsibility placed upon thousands of first responders, in communities large and small, nationwide. It also acknowledges that the size of our country and the deployment of local resources for daily emergencies make local first responders the only logical focal point of immediate response to attacks and other disasters.

A. INTEROPERABILITY PRIORITY #1

1. Salient Issues

1. Communications continues to be listed as a major issue in post-disaster after-action reports.
2. Hundreds of millions of dollars in homeland security funds have been spent to address the lack of "interoperable" radio communications.
3. The procedures employed by first responders during radio communications have not been adequately addressed.

3 "As James Lee Witt, former director of the Federal Emergency Management Agency (FEMA), is famous for saying, 'All disasters are local.'" Frances Edwards-Winslow, Ph.D., "Telling It Like It Is: The Role of the Media In Terrorism Response and Recovery," Perspectives on Preparedness, John F. Kennedy School of Government, Harvard University, August 2002, 2.

Nationwide, numerous reports have identified a problem with radio communications at the scene of disasters, yet the assumption has incorrectly been that the problem is largely a technical one; once disparate radios are connected, effective operational communications will result.[4] The posture, heretofore, has been that communications will improve if more users are added together on the same channels.

This is a flawed, counterintuitive assumption on two major fronts:

1. Superfluous radio transmissions contribute to the sensory overload of personnel at the emergency scene, clouding the attainment of an accurate operational picture for all involved.
2. Radio spectrum is a limited commodity—once it's full, it's full. Even if 700 megahertz channels are opened for full use later this decade, there will always be a practical limit to the number of people who can operate on a common platform before the quality of effective communications deteriorates.[5]

To optimize communications resources, we need to reexamine the policies and practices from a procedural perspective, selecting strategies that will facilitate effective communications.

The central questions of this thesis are:

4. Whether the dominant interoperability issue is procedural, and
5. Which procedural adaptations will enhance the crisis communications capabilities of the first responder community?

Some early indicators from the first responder community are just hinting at the need to address the procedural, *non-technical* aspects of facilitating emergency communications.[6] This is an issue we cannot simply "buy" our way out of by merely deploying more equipment.

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4 Newsday, Inc., "Audio: Dramatic Radio Transmissions from September 11," http://www.newsday.com/news/local/newyork/ny-tapesgallery,0,785678.htmlstory. (Accessed October 28, 2005).

5 While the Federal Communications Commission has reserved a block of channels for public safety use, many metropolitan areas are precluded from using these channels until a relatively few television stations migrate to digital television service. Congress is expected to act in compelling them to vacate the channels before the end of this decade.

6 "Provide training and technical assistance for public safety communications and interoperability." From Project SAFECOM's Near-Term Initiatives, The SAFECOM Program, U.S. Department of Homeland Security.

The mandate to the first responder community, post 9/11, has been to "fix" interoperability. Lapses in communication have been well-documented before the terrorist attacks of September of 2001, but it was that event which initiated a serious funding effort to address the issue.[7] Since that time, an estimated $1.5 billion has been allocated to homeland security, with heavy emphasis on radio hardware to facilitate interoperability.[8] Despite the focus on the word "interoperability" and the awarding of so many grants for the purpose, there is divergence in just arriving at a common definition.

Does "interoperability" refer to configuring a radio to be able to talk to any other radio that may be at the scene of an emergency response? At the same traffic accident, state police, local police, ambulance and fire personnel may be present. Are we advocating all of them hearing each other, interactively sending voice radio messages to one another? One definition, pre-dating 9/11, came from a cross-section of industry professionals assigned to the Public Safety Wireless Advisory Committee; they define interoperability as "an essential communication link within public safety and public service wireless communication systems which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method in order to achieve predictable results."[9]

To some, interoperability is intended for command-to-command use only. That sounds much more feasible than trying to coalesce all of the responders onto a single channel. One expert predicts "chaos" will result if we try to patch all agencies together, all of the time.[10] Experienced first responders will readily identify that their own segmented channels frequently become contentious during such incidents; with so many units talking, they cover/"step-on" one another, hampering effective communications.

7 "Inadequate and unreliable wireless communications problems have been plaguing public safety organizations for decades." Harlin R. McEwen, "Special Focus: Wireless Public SAFEty Interoperable COMmunications: Safecom," *Police Chief Magazine*, April 2004.

8 Davidson, Compatible radio, 2005.

9 Larry Irving, Final Report of the Public Safety Wireless Advisory Committee (PSWAC) to the Federal Communications Commission and the National Telecommunications and Information Administration, 1996, 49.

10 "Of course, interoperable communications doesn't mean that all these public safety groups will talk to one another all the time. That's a recipe for chaos, according to Boyd [SAFECOM Director David Boyd, Ph.D.]. What's needed is controlled, authorized access. 'When we talk about interoperability,' he says, 'we mean an ability for an officer to talk to whoever he or she needs to, when they need to and when authorized to do so.'" Pat West, "Family Talk Plan." *Fire Chief Magazine*, June 2004.

What will the exponential loading of the channel be like if four busy channels, loaded with agency-specific conversations are mixed on the same radio platform? Will the resultant "tower of babble" be helpful to everyone at the scene? Will first responders readily adopt the "less is more" posture needed when combining so many critical communications onto one channel, (as opposed to keeping them on appropriately diverse communications platforms, thus enabling agency-specific communications to continue?) First responders will tend to revert to daily habits in times of crisis, instead of modifying their use of the system when many agencies have been patched together, resulting in communications chaos, not panacea.[11]

It would be far more desirable to keep agencies on their routine operating platforms, clearing non-incident chatter on other incidents to separate channels. A compelling case can be made for an incident-specific common command channel among all agencies responding to the critical incident, but it must not be used as a poor substitute for a sound incident command system, which dictates that senior command personnel will congregate at a single incident command post, collaborate (face-to-face), coordinate, and communicate with their own personnel. The National Incident Management System (NIMS) has such a format at its heart and is supposed to be universally understood and applied, nationwide, as a condition of continued grant funding.[12]

While a lot of agencies say they know and use NIMS, evidence of its field application is weak, especially relating to multi-agency command from a single incident command post. Jurisdictions claiming to be enthusiastic adopters are often hard-pressed to show application of NIMS principles at emergency scenes, ranging in complexity from the New York City attacks on 9/11 involving two 110-story buildings, to more routine traffic accidents and building fires.[13] The reasons for slow or no adoption of NIMS

11 Christopher D. Wickens, John Lee, Yili Liu, and Sallie Gordon Becker, *An Introduction to Human Factors Engineering* (Upper Saddle River, NJ: Prentice Hall, 2004).

12 "Jurisdictions will be required to meet the FY 2006 NIMS implementation requirements as a condition of receiving federal preparedness funding assistance in FY 2007." The NIMS Integration Center, DHS/FEMA, National Standard Curriculum Training Development Guidance, October 2005.

13 "The NYPD and the FDNY were two of the preeminent emergency response organizations in the United States. But each considered itself operationally autonomous. Each was accustomed to responding independently to emergencies. By September 11th neither had demonstrated the readiness to respond to an 'Incident Commander' if that commander was an official outside of their Department." National Commission on Terrorist Attacks Upon the United States, Eleventh Public Hearing, May 18, 2004.

ranges from traditional resistance to change, to a state of general denial of the possibility that large-scale emergencies can happen in any given jurisdiction, to what may be the biggest factor of all—a reluctance to answer the "who's in charge" question within areas of historic turf battles, especially relating to police vs. fire department rivalries, and/or squabbles between various levels of government. Cordiality between agencies on the surface can belie any evidence of NIMS application in the field.

Traditionally, there has been a tendency by management in various organizations to devise hardware solutions for a whole range of challenges, instead of addressing human engineering issues.[14] It is understandable that a "turnkey" solution is hoped for; the purchase and delivery of new equipment signals tangible evidence that something is being done. The proof of concept comes only months, and sometimes years, later. Considering that the kind of incidents we are preparing for are the statistically unlikely exceptions, occurring only perhaps once or twice in a generation, it is difficult for new equipment to receive a thorough assessment of effectiveness, even in the most realistic training exercise environment. The response to Hurricane Katrina in the summer of 2005 is an early indicator, a weak signal perhaps, of the failure to really address the need regarding critical incident communications. These failures run counter to the expected result, especially after so much money has been expended with the expectations of instant communications improvement. "Police and other emergency agencies responding to Hurricane Katrina were plagued by the same communications problems exposed by the World Trade Center bombing in 1993, yet a solution is still considered years away."[15]

Radio interoperability is one of the many areas in which homeland security is evolving so fast that the need to change is outpacing the research. Much like the experience with the Y2K situation, where governmental agencies replaced a huge number of computers in a short period of time, the frenzy to answer the allegations of inefficient on-scene radio communications reported in the 9/11 Commission Report has led to the

14 Nita Lewis Miller, Naval Postgraduate School, Monterey, CA, and Lawrence G. Shattuck, U.S. Military Academy, West Point, NY., *A Process Model of Situated Cognition in Military Command and Control*, 2004.

15 Kerr, "Lack of Interoperability," October 16, 2005.

purchase of hundreds of millions of dollars of hardware.[16] Yet much of the problem is procedural and is likely to be exacerbated by patching radio users together, instead of achieving the intended outcome, which is to actually facilitate better communication.[17] New patching equipment is being deployed nationwide, with little or no guidance nor consensus for proper use. Because of the nature of radio system architecture, patching equipment actually makes previously "guarded" or well managed systems vulnerable, because for the first time, their airtime can be impacted by users outside of their system (basic radio system architecture is explained later in Section II).

Of particular interest is the deployment in recent months of NIMS and the formation of a center to create and issue standards on emergency scene operations, including communications (NIMS, 2004).[18] Another document receiving attention is the National Fire Protection Association (NFPA) *Standard on Disaster/Emergency Management and Business Continuity Programs* (Standard 1600), released in 2004.[19] It is currently undergoing debate at the committee level, and will likely undergo significant update and modification within its three-year review cycle. The 9/11 Commission Report focused considerable attention on dysfunctions present in the first responder community.[20] It should continue to be a catalyst for change for many years to come. It is already attracting a lot of attention to the subject, as evidenced by the designation of interoperability as being the top priority for grant proposal evaluations. We are also starting to see the inclusion of funding for training accompanying interoperability grant programs, signaling some recognition of the importance of attention to non-hardware solutions, yet specific examples of actual training applications are difficult to find. What constitutes "interoperability training" is vague and nonspecific, leaving room for the requesting jurisdiction to include the component in their grant application. As yet, there is no collective recognition of the need for improved human interoperability

16 Y2K refers to millennial change of calendars in 2000, which triggered concern for computer system stability.

National Commission on Terrorist Attacks, 2004.

17 West, "Family Talk Plan" (2004).

18 Department of Homeland Security, *National Incident Management System* (NIMS), 2004.

19 National Fire Protection Association, *NFPA 1600: Disaster/Emergency Management and Business Continuity Programs*, Quincy, Massachusetts, 2004.

20 National Commission on Terrorist Attacks, 2004.

communications procedures, as agencies presumably expect an out-of-the-box solution, based on patching radio systems together.

This thesis takes the reader through a global review of where the first responder community stands on addressing interoperability. With a specific intent to remain largely "non-technical," the basics of radio system architecture are reviewed, before shifting the focus to the main points: unique challenges present in emergency environments, physiological limitations experienced by people under stress, and practical work-arounds to allow some level of prioritized communications to occur.

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II. DESCRIPTION OF THE PROBLEM

A. CENTRAL QUESTIONS

Throughout the research for this thesis, a common factor emerged—better definition of the issue and more enlightened approaches for emergency scene communications are needed. Although examples of the need for better communication were easily found, the specific "interoperability" problem was generally ill-defined and the term was misapplied to include non-technical challenges. While the solution to emergency scene communication generally equates to a technical treatment of "how-to" patch one system to another, the larger question remains: What behavioral components (i.e. procedures, training) are required as a necessary adjunct to hardware interoperability communications solutions? Since the collective conscience of those within the homeland security discipline is still being developed, emergency scene communications issues represents something of a "moving target." The experiences of Hurricane Katrina are starting to produce additional lessons learned. In both man-made and natural disasters, it can be anticipated that the infrastructure itself will be damaged, by whatever catastrophic event has occurred, plus communications will be limited by the amount of radio traffic squeezed onto whatever radio spectrum remains operational. One hospital in Gulfport, Mississippi thought they had adequately prepared for communications contingencies before Hurricane Katrina, with back-up equipment—including satellite telephones and short-wave radios—yet the dish on the roof and towers they relied upon were damaged by the hurricane-force winds.[21]

The predictable outcome has occurred once again: universal reports of communications inefficiency. Putting aside the fact that some of the infrastructure blew away, along with everything around it, there are several stories from areas on the fringe, where the infrastructure was operational, but it was the *amount* of radio traffic and *manner* in which personnel used the system that led to the negative outcome.

21 The News-Sentinel, "Communications a Weak Spot in Hospitals' Disaster Preparedness," Fort Wayne, IN, October 16, 2005.

B. SCHOOLS OF THOUGHT

One major school of thought that can't be ignored is the "school of denial!" Many in the first responder community do not acknowledge that there is an issue to be addressed. While failed communication is bemoaned as an after-action frustration, few are looking inward for solutions.

We have heard the phrase "failure of imagination" used in the 9/11 commission report and now it is starting to surface regarding the Hurricane Katrina response.[22] Insomuch as homeland security and defense is focused on the intentional acts of persons bent upon causing harm to us, we are starting to see a melding of homeland security and defense with the broader discipline of "emergency management," in recognition of the value of pursuing force multipliers consistent with an "all hazards" approach. We do not have a very good track record of anticipating situations and circumstances, before a calamity occurs. Policy makers seem content to form a defense against the kinds of situations recently experienced, rather than enthusiastically contemplating a full range of unusual events, including both those that are manmade and those occurring naturally, that can impact any given jurisdiction. It is a natural inclination that we therefore do not contemplate operational subsets, like communications support, if we deny the possibility of the entire situation occurring in the first place. Not many people even know they need to fix communications procedures used for inter-agency coordination. General agreement on the existence of a problem is not yet prevalent, but should be anticipated eventually as trial and error with radio patching equipment leads to unexpected radio system congestion and resultant ineffective communication. If nothing else, the amount of money expended on interoperability is going to attract scrutiny if we still label communications failure as our most frequent post-incident concern, despite deployment of costly hardware.

22 National Commission on Terrorist Attacks, 2004, 339.

Evan Thomas, "How Bush Blew It, Bureaucratic timidity. Bad phone lines. And a failure of imagination. Why the government was so slow to respond to catastrophe," *Newsweek*, September 19, 2005.

C. DIVERGENCE POINTS: CONVERGENCE OPPORTUNITIES

Of those who do agree on the presence of an issue, commonality can be found in approaches involving common governance and procedural dictates.[23] To some degree, recognition that communication procedures need to be changed may grow out of the NIMS mandate. NIMS is poised to force a solution, via funding control, ostensibly because agencies have failed, in the absence of external pressure, to identify the need and craft a viable solution. This is an interesting counterpoint to the common phrase that the government wants to craft "national solutions" for homeland security, but not "federal" ones, since NIMS has become a de facto, unfunded federal mandate. Hurricane Katrina has hastened further calls for federalized solutions. Our window of opportunity, to devise solutions of our own design, as a first responder community, is slowly closing. Since we have failed to collectively see the need and act to reverse years of parochial, myopic procedures and customs, we can anticipate more mandates by those distanced from the realities of working in the field.

There is general agreement on the need to improve emergency scene communications.[24] If, as predicted, the technical solutions to improve interoperability don't have the desired affect (emergency scene communications enhancement), we should be ready to shift focus to the necessary procedural modification. The timetable of such realization and implementation of procedural enhancements and policy deployment remains to be seen, but the solutions will likely be similar, with only minor stylistic differences in approach, in deference to regional needs and nuances.

D. MANDATE NOT AN AUTOMATIC SOLUTION

In reviewing the early warning beacons on interoperability implementation concerns, some common threads are evident in the establishment of written procedures. Despite the para-militaristic format of the first responder community, who are generally bound by written rules and Standard Operating Procedures, *immediate* improvement of

23 National Task Force on Interoperability, "Why Can't We Talk? Working Together To Bridge the Communications Gap To Save Lives. A Guide for Public Officials," February 2003. http://www.safecomprogram.gov/SAFECOM/library/interoperabilitybasics/1159_nationaltask.htm. (Accessed October 28, 2005).

24 Harlin R. McEwen, "Special Focus: Wireless Public SAFEty Interoperable COMmunications: Safecom," *Police Chief Magazine*, April 2004.

performance can be challenging since all organizations, (some much more than others), have rules on the books that are slow to become accepted into practice. Procedural changes, such as new ways of operating, involve more of a "corporate cultural" change, as opposed to simply developing new dictates, and expecting to see an immediate result. An example of such reticence to change, even in the face of logic, is seatbelt use by police and fire personnel. One recent study showed about 20% of the police officers seriously injured in traffic accidents were not wearing seatbelts.[25] So paradoxically, merely legislating something to public safety officials will not guarantee compliance. Military partners have expressed surprise at the non-standard format of first responder service delivery and the jurisdiction-specific autonomy to make rules and unevenly enforce them.

The cultures within the first responder community are unique. Common features, such as resistance to change, an "us-against-them" mentality, defense mechanisms from constant exposure to crisis, a tendency to have limited external interests and contacts, combined with a mentality of heroic entitlement to bend rules and receive special treatment creates considerable challenges when attempting to implement change.[26] Acknowledgement of the "first-responder mentality" will be necessary since we need to craft new rules for people with a high degree of resistance to change, and established comfort zones closely associated with personal convenience and safety.

E. WHAT TO CALL IT?

This thesis topic presents the opportunity to be among the first to synthesize analogous information bridging what other disciplines have learned about human tendencies exhibited while communicating under stress. One of the interesting challenges entails what to call this procedural and behavioral subset of first responder communications functionality. First responders have all heard of "interoperable communications," but what do you call it when we are referencing the non-technical

25 Jehle Dietrich von Kuenssberg, MD, David G. Wagner, James Mayrose, Ph.D., Usman Hashmi, "Seat Belt Use By Police: Should They Click It?" *Journal of Trauma-Injury Infection & Critical Care* 58, no.1 (January 2005):119-120.

26 Daniel A. Goldfarb, Ph.D., Gary S. Aumiller, Ph.D., "10 Reasons Cops are Different," www.heavybadge.com. (Accessed August 23, 2005).

impediments to adequate emergency scene communications? “Crisis Communications” is one term that may fit, yet that has a larger connotation in the private sector referring to media relations in high profile situations like corporate take-overs, product tampering, or internal financial scandals. In the public sector, the term is used with Public Information functions to refer to the process of communicating with the public through the media. Nothing else quite rolls off the tongue yet; the predicament of what to call such non-technical communications competence is likely to find its own level ground as new agencies within the Department of Homeland Security are created to address training and develop the associated standard operating procedures for communications.

The press release shown below, issued September 27, 2004, by the Department of Homeland Security, is a good example of the vagueness we’ve seen thus far.

> Today, Secretary Ridge formally unveiled the Department of Homeland Security’s Office of Interoperability and Compatibility that will strengthen the national partnership of local, state, and federal leadership to achieve emergency response interoperability in every community in the country. This new office, part of the Science & Technology directorate, will also expand the Department’s interoperability efforts beyond communications to include equipment, training, and others areas of need as required. The office will incorporate all Homeland Security interoperability programming, leveraging existing efforts to ensure better coordination and accountability for federal government activities relating to research and development, testing and evaluation, standards, technical assistance, training, and grant funding for interoperability.[27]

The next step is to transition beyond such vagueness, by addressing specific procedures necessary to derive maximum benefit from the new equipment being deployed for homeland security communications improvement. Communications procedures should include teaching ways to economize use of communications assets, by placing priority on life-safety radio transmissions and practical alternatives for communicating during emergencies. Improved procedures should address application of NIMS incident management principles that emphasize the use of staging areas, sector

27 U.S. Dept of Homeland Security, Press Release: *U.S. Department of Homeland Security Launches Office of Interoperability and Compatibility; Offers States and Locales Tools for Improving Public Safety Communications Interoperability*, September 27, 2004.

control by assigning functional units under the control of a sector officer, and application of face-to-face communications practices.[28]

F. RADIO SYSTEM 101

The focus of this thesis is particularly intended for first responders and associated policy makers, who typically possess only a rudimentary understanding of radio system architecture. The following brief discussion of radio system infrastructure principles will provide a baseline understanding for the reader.

Since the proliferation of cellular telephones during the last few years, average citizens have had the opportunity to experience the inherent limitations of relying on a portable radio device. People using cell phones consider them to be a close cousin to corded telephones in homes and businesses, and while the net effect is similar *most of the time* (a call is successfully completed), there are periods of limited and lost service and the audio consistency and quality are decidedly second-rate. Experienced users of cell phones can relate to dropped calls, garbled audio, inability to access the system due to remoteness or traffic load on the network, and dead batteries. Public safety first responders experience many of the same things as they use their radio equipment.

Much like the networks built to support cellular telephones, public safety radio networks utilize a radio infrastructure, usually antennas placed on towers, with transmitters and receivers at the base, often interconnected in some manner to enable use of portable radio devices within the area served. Each jurisdiction makes a policy decision on the level of radio coverage they wish to pursue (and fund). "Most public safety specifications require a 95% level of coverage. The last few percentage points of coverage can drive up the cost of a system exponentially unless there is a cost-effective alternative to traditional tower sites."[29]

In radio circles, there is theoretically no such thing as 100% coverage since the vendor cannot control all of the influences that may hamper a specific radio device from

28 Jonathan S. Smith, "Work Channel: A Practical Guide to Improved Radio Communication, A Guide for Public Officials," *9-1-1 Magazine*, July/August 1997.

29 Mobile Radio Technology, "Coverage proof of performance: Hocus-pocus or real world?" May 1995.

working at a given location.[30] Coverage inside buildings is especially problematic since adequate system coverage can be present in the street, outside, yet the deeper the first responders get into the building, the less likely it becomes that their radio will operate at peak efficiency. Some agencies have successfully deployed portable repeater equipment, but it takes considerable resources, dedicated to the purpose, just to provide this support function in the right place, at the right time. Such an arrangement is beyond the capabilities of many jurisdictions. It is possible to permanently install signal booster equipment within significant structures, yet cost, jurisdictional and technical barriers make this an inconsistent solution.

Beyond the specifications and technical capability of a given system, the portable devices, by their very nature and purpose, are remote from the home system and can find themselves contending with other interference-producing influences, such as other radio systems (public safety and commercial), interference produced by other technologies, including industry and consumer products intended for other purposes, plus just the general limitation of high-tech hardware operating in harsh environments, e.g. fires, crimes, weather extremes, etc.

These realities have not modified expectations by the end users or policy makers. If anything, the hundreds of millions of dollars spent on interoperability equipment shows we have collectively placed the emphasis on using radio devices at catastrophic incidents as the primary means of providing crew safety, efficient delivery of life-saving services and overall situational awareness for senior management.[31] Few of us would place our lives in the balance based on the continued operation of our cell phones being ready to deliver every word to us, yet that is exactly what first responders do with the radios provided to them. For most first responders, their portable radio is their most frequently used piece of equipment.

1. Radio System Limitations

All radio devices operate within the radio frequency spectrum, controlled by the Federal Communications Commission (FCC). Some devices used around the home, such

30 Ibid: "There is no such thing as 100% coverage, and anyone who tells you different is suspect."

31 Jennifer C. Kerr, "Lack of Interoperability Hampers Agencies," *Associated Press*, October 16, 2005, http://www.wjla.com/news/stories/1005/269201.html. (Accessed December 12, 2005).

as garage door openers, wi-fi networks, walkie-talkies, and many remote control devices, operate at such low power levels, licenses are not necessary and there is little chance of conflicting with other units. Once a device needs to communicate at a greater distance, it is necessary to operate at higher power levels, requiring FCC control. The number of radio frequencies available for public safety use is limited. While efforts are underway to reallocate more frequencies to expand capabilities, the reality in most areas is first responders will continue to operate within a limited set of frequencies, for the foreseeable future. As such, radio spectrum is a limited commodity, in that there is a limit to the amount available for any given jurisdiction to use. Even where extra frequencies are available, the cost of hardware and infrastructure improvements provides practical financial limitation to many agencies.

Returning to the cellular telephone analogy, there is a similar limit on the number of radio frequencies utilized at a specific cell phone tower, as well as a limit on the number of telephone lines able to be accessed on the switched telephone network. The cellular telephone service provider may hold thousands of frequency licenses nationwide, but deploys only a handful at each tower site. The limitation of the phone network to handle calls varies from area to area, and is not well advertised or acknowledged by the telephone carriers. Much like the practical limitations on public safety radio systems, telephone networks are not sized for even half of all users to talk simultaneously.

2. Typical Trunked Radio System Configuration

Even if it were possible to assign many more frequencies to an incident, assigning too many is a very real possibility since the addition of each new talkgroup (trucked systems) or dedicated channels (conventional systems) disperses potentially critical communications over a wide group of segmented audiences.[32] This has the potential to cause:

32 Trunked Radio System: A system that integrates multiple channel pairs into a single system. When a user wants to transmit a message, the trunked system automatically selects a currently unused channel pair and assigns it to the user, decreasing the probability of having to wait for a free channel for a given channel loading. Conventional Radio System: Non-trunked, similar to telephone party-line in that the user determines availability by listening for an open channel. Booz Allen Hamilton Inc., report for the Public Safety Wireless Network (PSWN), Comparisons of Conventional and Trunked Systems, May 1999. http://www.safecomprogram.gov/NR/rdonlyres/F04A685D-5902-4655-BBBB-7251DCDF4693/0/Conventional_Trunked_Radio_Systems_Comparison_Report.pdf. (Accessed November 3, 2005).

1. a loss of adequate situational awareness development, for the responders at the scene, as well as support personnel monitoring the incident from a distance. Such personnel are dependent upon what they hear to form an adequate operational picture. If a key element is missed because it is said on an unmonitored frequency, the "missing piece of the puzzle" may distort the true picture of what is occurring.
2. operational confusion due to sensory overload from so much being said simultaneously. Like the proverbial "tower of babble," key points can become lost in multiple conversations occurring at the same time.
3. safety concerns of someone calling for help on a channel beyond dispatcher or incident commander monitoring capability. First responder personnel rely on portable radios as their lifeline for assistance if they become trapped or disoriented. Calls for help may go unmonitored by anyone in a position to assist if they occur on an obscure, unmonitored frequency.

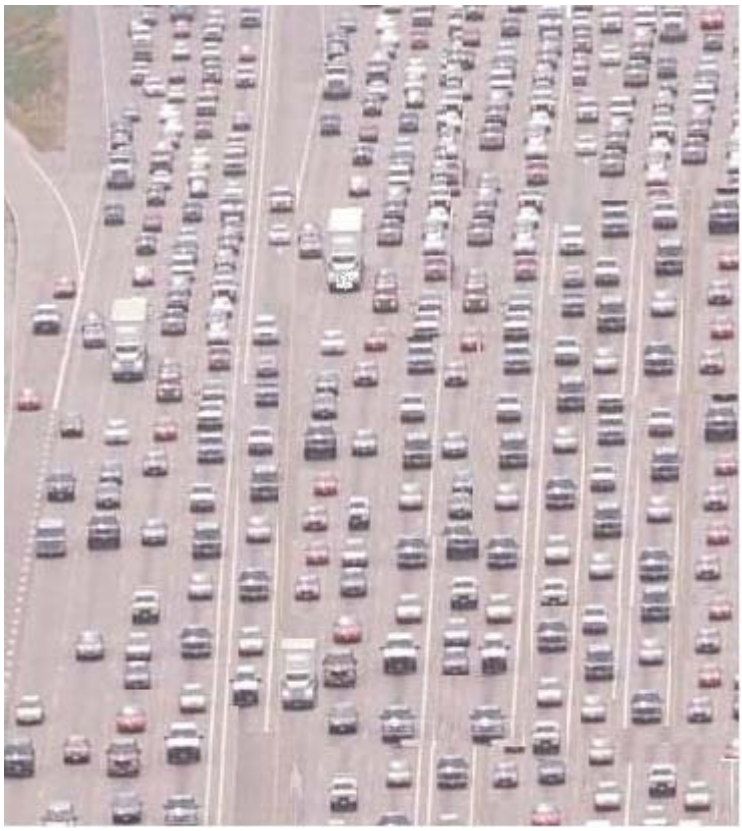

Figure 1. Radio System Traffic Analogy.

Similar to lanes of traffic on a highway, there is a limit to the number of radio channels with simultaneous conversations that can be supported. During peak loading, a

conversation is interspersed among many other conversations. In trunked systems, a busy signal is produced when no communications path is available. Those using conventional systems will "cover" one another if too many people talk at once, which significantly reduces the effectiveness of those present at the emergency to communicate.

As depicted in figure 1, radio system traffic is analogous to automobile traffic on the freeway—where there is a limit to the number of vehicles that can be handled with a given number of lanes. Interoperability equipment potentially merges additional "lanes of traffic" onto the same "highway," theoretically producing greater tie-ups, not less.

G. EMERGENCY SCENE CHALLENGES

There is a tendency by policy makers isolated from emergency scene experiences to minimize the difficulties encountered by those responding to an emergency and to attempt to draw strategies from the literature on organizational theory and contemporary management techniques. The uninitiated may mistakenly assume that emergency scene decision making is similar to bureaucratic policy development, in which the luxury of time often allows for an exhaustive examination of alternatives, before selecting a course of action.

First responders are placed in a very unique and precarious environment upon arrival at an emergency. Everything must be done in a time-compressed environment, with commitment to strategic decisions made in near-instantaneous fashion. Many of the commitments made in the early stages of the incident, regarding considerations such as the placement of personnel and equipment, calling for additional help, and the decision of where to concentrate efforts will largely influence the range of options available to incident commanders for the remainder of the incident. The first 20 minutes of a major incident are crucial to rescuing "savable" victims, removal of people from danger, and setting the organizational structure for the hours and perhaps days to follow.

It is important for policy makers to appreciate that portable public safety radios issued to first responders are a critical lifeline used in meeting routine issues of personal safety and operational efficiency. The portable public safety radio is the first responders' primary means to:

- develop situational awareness,
- receive task assignments, and
- attend to issues of life safety (public and personal).

It is also important to the wider audience now entering the interoperability debate to fully appreciate that despite characterizations on television and movies, first responders are involved in true life-and-death situations a very small portion of the total time on duty. Also, their functioning in multi-jurisdictional/multi-unit environments is relatively rare in contrast to the overall workload. In essence, the average police officer works solo, and perhaps interacts with one or two fellow officers as back-ups, a handful of times per shift or work week. Similarly, the typical firefighter is part of a two-to-four-person team, occasionally deployed with several similar work units to major incidents. As such, the experience base, and anticipatory psyche is that the risks and stressors will be low to moderate, and the radio traffic will be similarly low to moderate, on the typical work day. This reality works counter to good habit development and appropriate anticipation of efficient and effective communications skills and tactics, during intense, high-risk, cataclysmic events, since they occupy what may be less than one percent of all their time on duty, during the span of an entire career.

This tells us that the daily routine of first responders does little to prepare the average first responder to face a communications-intense environment, typical of large-scale disasters. Yet the universal reaction by response personnel at after-action reviews has been shock and indignation over failed communications at disaster scenes. We must remain mindful that the net results are a product of a process whereby the daily radio practices are accelerated and multiplied, with a dramatic increase in communications by the responders at an incident, *and* these communications are squeezed into limited communications systems. Large-scale emergencies challenge the emergency community to find new ways to prepare personnel for situations which will be uncomfortable, unfamiliar, and counter-intuitive. While there are things that can be done to stretch the communications resources deployed at emergency scenes, the logical approach is to manage the input-side (amount of radio talking done at the scene), too.

1. Criteria to Judge Outcomes

Rather than lumping all communications issues into one category, it is useful to determine an agreed-upon system of communications issues sub categories to itemize and describe the types of issues encountered at a given incident or exercise. These issues may include:

- Radio system coverage
- Human interface with the technology
- "Airtime" – ability to access a system to deliver a message
- Need to talk to a responder from another agency at the same incident
- Stress-influenced ineffective message delivery
- Non-standard terminology
- Failure to minimize radio traffic to only essential communications

This provides a foundation of understanding, based upon broad categories, rather than the heretofore over simplification of "communications were bad," therefore, "interoperability is needed."

III. PERTINENT PARALLELS FROM OTHER SECTORS

The biggest frontier for the first responder community, in terms of efforts targeted at improving communications, will be to examine the body of knowledge in the behavioral sciences and apply it to improve the operational efficiency of first responders engaged in homeland security.

Work has been done for decades to study and predict how people will react in a variety of situations. As such, there are pertinent analogies to the world of emergency services, providing that they are appropriately vetted for applicability to the unique culture and realities of those delivering emergency services in our communities.

A. MILITARY

Students at the Naval Postgraduate School (NPS) are ideally positioned to glean information from classmates, faculty and NPS resources on how the U.S. military communicates during operations. Throughout their course of study, community first responders have had the opportunity to compare notes with experienced military personnel. A number of analogies can be drawn, to answer the question at hand—how can community first responders communicate in a more effective manner?

The U.S. Navy has undertaken significant efforts to better understand how their personnel react under stressful communications situations. "Two incidents in the 1980s highlighted the need for improvements: The USS Stark was attacked by two Exocet anti-ship missiles and was nearly sunk, and the USS Vincennes mistakenly shot down a civilian Iranian airliner during a surface battle with Iranian naval forces."[33]

1. Vincennes

The 1988 downing of a commercial airliner by the USS Vincennes offers insight into the challenges of making time-compressed decisions, based upon monitoring of

33 Lt. Sharif H. Calfee, U.S. Navy, and Neil C. Rowe, Institute for Modeling, Virtual Environments, and Simulation (MOVES) and Computer Science Department, U.S. Naval Postgraduate School. Multi-Agent Simulation of Human Behavior in Naval Air Defense, http://www.cs.nps.navy.mil/people/faculty/rowe/calfeepap.htm. (Accessed September 11, 2005).

decision support system displays, while lives hang in the balance. In one of the most studied events involving people using technology to glean information and make decisions, a number of vulnerabilities and shortcomings were identified, despite the availability/use of significant technological assets, which represented the state of the art at that time.

"On 3 July 1988, the USS Vincennes …, operating in the Southern Persian Gulf as a unit assigned to Commander, Joint Task Force Middle East, downed a civilian airliner, Iran Air Flight 655 on a routine scheduled flight from Bandar Abbas to Dubai, with two SM-2 [missiles]."[34] The 290 civilians on board the plane were killed following the execution of orders to shoot the plane down when it appeared to be hostile. The Fogarty report delineates how the order to shoot followed a series of warnings, coincidences of timing, and earlier hostile acts by enemy aircraft in the area.

2. Post-Vincennes Introspection

In the years following the USS Vincennes incident, the U.S. Navy searched for greater insight into the question of how people react in high-stress environments and what can be done to improve the quality of decisions made under such circumstances.

To develop answers and solutions to these challenges, the Tactical Decision Making Under Stress (TADMUS) program was initiated in 1990, with the goal of designing a decision support system (DSS) based on, "(a) an understanding of the cognitive strategies people use when dealing with the types of decisions required in tactical decision making and (b) incorporating human-computer interface design principles that are expected to help compensate for human cognitive processing limitations."[35]

34 W. M. Fogarty, Formal Investigation into the Circumstances Surrounding the Downing of a Commercial Airliner by the U.S.S. Vincennes (CG49) on 3 July 1988 (letter to Commander in Chief, U.S. Central Command), Washington, DC: U.S. Navy, 1988.

35 Susan G. Hutchins, "Decision making errors demonstrated by experienced naval offices in a littoral environment," in C. E. Zsambok and G. Klein, *Naturalistic Decision Making* (Mahwah, NJ: Erlbaum, 1997), 207-215.

Teams of command-level antiair warfare personnel were brought into a simulator environment, and engaged in a series of scenarios (which were praised for their realism), while researchers recorded the decisions made by the personnel, for later scoring and analysis.[36]

Performance was improved when decision support, in the form of a user-centered decision support system (DSS) was provided to the decision makers. Situational awareness was enhanced by improving the visual displays provided. The DSS had modules to help keep track of actions taken, or awaiting attention, as opposed to the traditional expectation of the individual relying upon memory to remember which tasks need to be performed and when.[37] Other modules synthesized parametric data and provided graphic presentations to depict what tracked aircraft were doing along with recommended actions to be taken. The sheer volume of information flowing in a compressed timeframe produces a high cognitive workload environment, one that acknowledges that short-term memory degrades under stress, further limiting the cognitive capabilities of the individual.[38]

Reliance on memory is the way many first responder agencies have historically operated, with informal policies and traditional customs and "rules of thumb" being more the operational norm than any formal, standardized approach. Commanders of first responding agencies have resisted use of written checklists and marker boards, partly because of logistical issues (weather, pace of the emergency, and they are more cumbersome) and partly because it represents a departure from the historic methodology handed down from one generation of responder to the next. Peer pressure and resistance to change produce less than enthusiastic adoption of alternate methods, yet the TADMUS

36 Susan G. Hutchins, "Decision making errors demonstrated by experienced naval offices in a littoral environment¸ ¡n C. E. Zsambok and G. Klein, *Naturalistic Decision Making* (Mahwah, NJ: Erlbaum, 1997), 207-215.

37 DSS modules were designed to support the decision maker by reducing the number of items they had to remember (by displaying all pertinent data regarding the situation), and aiding their attention allocation process by prompting them on which actions needed to be taken and which tracks (aircraft) required their attention.

38 Susan G. Hutchins (Research Associate Professor, Naval Postgraduate School), Interview with author, July 22, 2005, Monterey, CA. Situational Awareness was enhanced by providing visible displays that facilitated the decision maker's ability to rapidly understand what a track is doing..

program documents the value of using a well-designed visual display instead of relying on memory to recall important tactical information and to keep track of actions taken and actions still pending.

Other Navy findings, pertinent to the first responder community, involve recognizing the inefficiency of expecting people to recall vast amounts of information from training and experience, plus the effects of "cognitive biases."[39] Several researchers have documented the susceptibility of decision makers to cognitive biases when operating under stress, i.e., high workload, time pressure, information ambiguity. Decision makers are also susceptible to cognitive "tunnel vision," a situation where they focus on a narrow set of cues when under stress, even to the exclusion of critical matters awaiting attention. Another example of commonality between military and first responder decision making is the condition of decision confirmation bias—commanders tend to build upon assumptions made earlier in the decision sequence, even if they were based upon limited or even erroneous assumptions.

The incident commanders in New York City on 9/11 were faced with limitations on their field of view (among tall buildings) and perhaps a degree of cognitive bias, based on their response to the same complex of buildings for a lesser attack in 1993.[40] It is during such periods of limited field of view when reliance on communications systems for development of an accurate operational picture is most acute.

B. FIRST RESPONDER OPERATIONAL ENVIRONMENT

The average incident commander at the scene of a community emergency generally starts out with little more than a portable radio, and perhaps a clipboard of some sort. The largest first responder departments in the country may deploy drivers and aides

39 "A cognitive bias is a tendency to mentally process information in a particular way…people tend to seek out information that confirms their preconceptions and to discount information that disconfirms their preconceptions." Jeffrey P. Richer, Ph.D., Scottsdale (AZ) Community College, Unpublished curriculum, http://www.sc.maricopa.edu/sbscience/ psy266/lessons/essays/essay9.html. (Accessed October 28, 2005).

40 "People watching on TV certainly had more knowledge of what was happening a hundred floors above us than we did in the lobby. Certainly without any information, without critical information coming in, the cumulative effect of the information coming in, it's very difficult to make informed critical decisions without that information. And it didn't exist that day. Our communication systems were down." Peter Hayden, Assistant Chief, FDNY, Staff Statement Number 13, National Commission on Terrorist Attacks, 2004, 18.

with command officers, but they are the exception of all emergency responses made nationwide. Eventually, command assistance, support, and technology are usually deployed on-scene, as an incident escalates, but the variance in capabilities to fund, staff, configure and operate under pressure vary greatly, nationwide. While the level of support eventually brought in to a large-scale disaster assists the overall response and recovery phases, it is during the first few minutes of a disaster when the incident commander is responsible for a wide array of critical duties:

- proper size-up of the event, (used in first responder circles to mean the initial assessment regarding the scope and magnitude of the incident)
- establishment of safety zones and warning those in the path of the hazard
- protection of any potential crime scene
- calling for additional resources
- coordinating the initial response, optimized for rescue of "savable" lives

Research indicates teams who exhibit strong communications skills ("high performing teams") were found to have, "a clear sense of roles and expectations, greater team productivity, enhanced collaboration and problem solving, improved working relationships, greater job satisfaction, fewer destructive conflicts and a sense of personal achievement."[41]

First responders frustrated by poor communications are at a disadvantage since they are at the point of greatest need when they are dealing with a crisis. Responders typically are concentrating on calling for, and coordinating the use of, unusual resources needed to respond to the crisis situation. At the very time they need *optimal* facilitated collaboration, due to the challenges present at most disaster scenes, e.g. role confusion, high emotions, and tenacious relationships history, the elevated personal conflicts associated with poor communications will tend to pull them in the opposite direction from the necessary teamwork and collaboration.

41 Melanie Becker, James Burns-Howell, John Kyriakides, Derek Smith, "IS Team Effectiveness Factors and Performance," Department of Information Systems, University of Cape Town, South Africa, 1997. http://www.commerce.uct.ac.za/informationsystems/Research&Publications/Pubs2000/ER05.pdf. (Accessed November 8, 2005).

C. ALTERNATIVES: TEXT, VISUAL DISPLAYS, NEW TECHNOLOGY

1. Remote Control Aircraft

Military planners envision a future whereby Unmanned Aerial Vehicles (UAVs) will fill the sky and conduct missions ranging broadly from defense to commercial interests, both foreign and domestic.[42] There will be an acute need to optimize the remote control of such aircraft, so that manned aircraft are not interfered with, people on the ground are protected from danger, and aircraft itself is preserved from crash landing. Something as simple as the perception and proper reaction to turbulence becomes reflexive to a human pilot, but will demand elaborate provisions to handle remotely. Economy of scale pressures will also invite the notion of one operator flying multiple aircraft. How much is *too* much and what can be done to optimize the visual displays used by the remote pilots? Those questions are just starting to be researched, but preliminary indications point toward the need for better, intuitive design of visual displays, before even a one-for-one remote pilot configuration becomes practical over the common practice of two-person ground crews- "one responsible for airframe control and the other for payload sensor control. Such crew structure is merited in light of findings that the assignment of airframe and payload control to a single operator with conventional UAV displays can substantially degrade performance."[43]

The value of this preliminary research for first responders is twofold:

1. It validates that the human interface with technology is not all it can be, and if users depend on display of data, as a substitute for radio transmissions, it will have to be displayed in such a way as to be useful to the person operating under pressure. In other words, the mere presence of the information, somewhere on the screen, does not guarantee operational value.
2. As further research develops for optimizing operator information displays for UAVs, the first responder community should monitor the findings. The opportunity exists to identify, modify and adopt them to the multi-sensory challenges present for communications operators and incident commanders at the scene of emergencies.

42 Jason S. McCarley, and Christopher D. Wickens, "Human Factors Concerns in UAV Flight," Institute of Aviation, Aviation Human Factors Division, University of Illinois at Urbana-Champaign. (Dr. William K. Krebs, Office of the Chief Scientist for Human Factors, General Aviation Human Factors, Federal Aviation Administration), 2004, 24-28.

43 Ibid., with citation from L. Van Breda, Operator Performance in Multi Maritime Unmanned Air Vehicle Control (Soesterberg, The Netherlands: TNO Human Factors Research Institute, 1995), 27.

2. Headset Design

> Battle management command and control (BMC2) as performed by operators of tactical air battle management platforms such as the U.S. Air Force's E-3 Airborne Warning and Control System (AWACS) or E-8 Joint Surveillance Target Attack Radar System (JSTARS), or the U.S. Navy's E-2C Hawkeye, is a communications-intensive activity. Weapons directors and mission crew commanders on these platforms are required to monitor as many as eight simultaneous communications channels against a background of moderate to high ambient cabin noise while performing a number of visual and manual tasks, the combination of which in the heat of battle is challenging even for the most highly trained operators. Researchers at the Air Force Research Laboratory's Human Effectiveness Directorate have been investigating two technologies that may ameliorate this problem: active noise reduction headsets and spatial intercoms.[44]

While it may be impractical for the "first" of the first responders to operate with headphones, it's apparent that headphones should be considered for people detailed for communications support at the scene of emergencies. This notion challenges the status quo of how first responders communicate over radios, i.e., generally on a portable radio with some form of open speaker, and it indicates a need to reexamine the equipment itself.

Bolia, et al., examined the benefit of technologically modified headphones, in which the illusion of spatial separation is accomplished via digital technology. This helps because of a phenomena known as the "cocktail party effect," "which refers to the fact that, at a cocktail party, in the midst of perhaps scores of people engaged in dozens of conversations, an individual can still make sense of what the person she is talking to is trying to say, despite the fact that if the same conversations were played (simultaneously) to the individual over mono headphones she would be hopelessly lost."[45] The effect created for the listener using such headsets is depicted in Figure 2, showing the study's demonstrated value of providing separation in the communications sources.

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44 Robert S. Bolia, W. Todd Nelson, Michael A. Vidulich, Brian D. Simpson, and Douglas S. Brungart, *Communications Research for Command & Control: Human-Machine Interface Technologies Supporting Effective Air Battle Management*, Air Force Research Laboratory, Wright-Patterson Air Force Base, OH. http://www.dodccrp.org/events/2005/10th/CD/papers/279.pdf . (Accessed November 10, 2005).

45 E. C. Cherry, "Some Experiments on the Recognition of Speech, With One and With Two Ears," *Journal of the Acoustical Society of America* 25 (1953): 975-979.

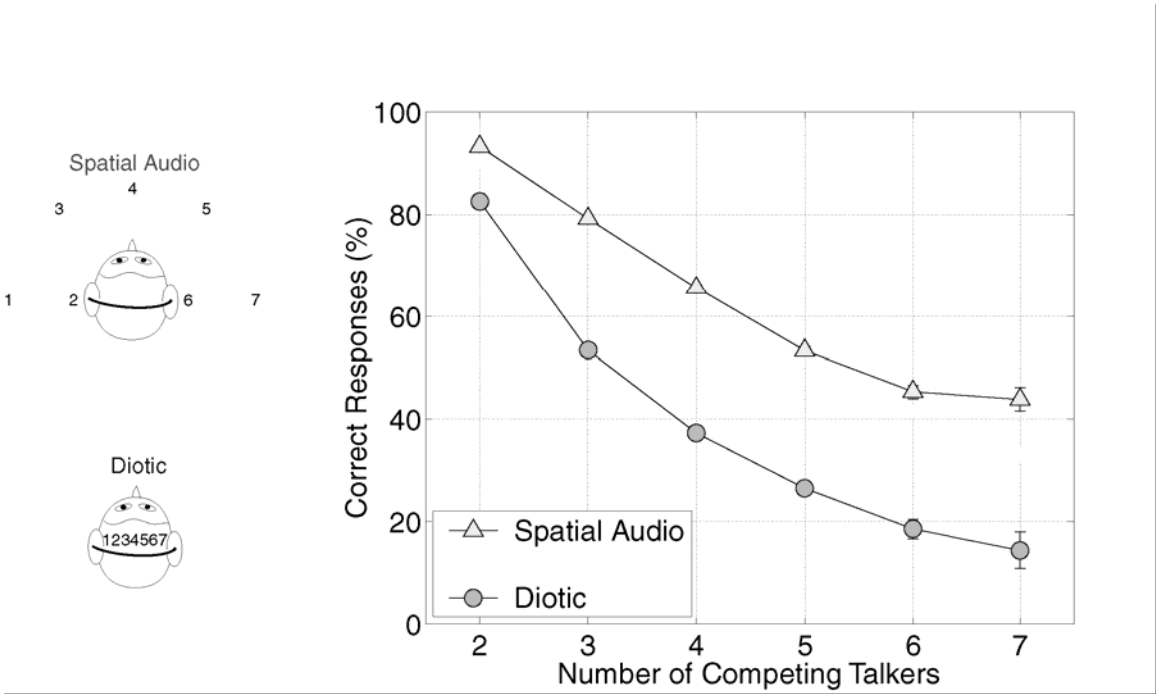

Figure 2. Spatial vs. Diotic Audio Sources (From E. C. Cherry, "Some Experiments on the Recognition of Speech, With One and With Two Ears," Journal of the Acoustical Society of America 25 (1953): 975-979)

Audio comparison of overall performance with spatial-audio and diotic-audio displays (shown on the left of the figure) was compared in a multi-talker listening task with all male talkers. The results (shown on the right) have been plotted as a function of the number of talkers in the trial. Error bars represent the 95% confidence intervals for each data point.[46]

Results of this study suggest that first responders should anticipate that listening to multiple channels at the same incident will be difficult, and if attempted, equipment modifications should be developed.

D. BEHAVIORAL SCIENCES

1. Emotional Component

There are some basic, predictable human responses, especially those associated with our physiological programming, such as the "fight or flight" response, which are

46 Bolia, Nelson, et al., *Communications Research*, 7.

involuntary and common across all people.[47] Consider the emotion in the voice of the radio announcer in the famous recording of the Hindenburg disaster ("oh, the humanity…").[48] The emotion is very similar to that of emergency personnel transmitting at the scene of an emergency today, therefore valid and valuable analogies exist in the research literature.[49]

2. Physiological Influences

A lot is going through the head of an incident commander at the scene of an emergency. The amount of sensory input the brain has to process is immense. Just the process of *responding* to the emergency takes a toll on the individual, considering that the address must be recognized, an appropriate access route selected, traffic to be maneuvered through (especially with lights and sirens), and attempts to develop a mental picture of what is occurring, based on updates received en route. First responders may arrive in an emotionally compromised state, as contrasted with those working in stable environments, before they are even called upon to perform critical decision making and clearly articulate commands to others. When asked to describe the process by which decisions were arrived at, a firefighter in one study indicated that he wasn't even aware that he *was* making a decision; it was more of a reflexive reaction than a conscious contemplation of a range of options to be acted upon at a later date.[50] This is sometimes referred to as intuitive decision making and it reflects that people who are experts in their domain are so highly experienced they react automatically without conscious thought.

Another major influence inhibiting clear communication is a state of *expressive suppression*, defined as "consciously inhibiting emotional expressions while emotionally aroused."[51] First responders force themselves to "stay calm" and control the emotion in their voice. In one study, it was found that when people suppress natural emotional

47 W. B. Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage: An account of recent research into the function of emotional excitement,* (2nd edition) (New York: Appleton-Century-Crofts, 1929).

48 Herbert Morrison, The Hindenburg Broadcast, May 6, 1937. http://www.eyewitnesstohistory.com/vohind.htm. (Accessed October 15, 2005).

49 Nancy J Rigg, "Maintaining Control, North Hollywood Bank Robbery & Shootout," *9-1-1 Magazine* (February 28, 1997).

50 Gary Klein, *Sources of Power: How People Make Decisions* (Cambridge, MA: Massachusetts Institute of Technology, 1998), 16.

51 E. A. Butler, B. Egloff, F.H. Wilhelm, N. C. Smith, E. A. Erickson, and J. J. Gross, (2003). "The Social Consequences of Expressive Suppression," *Emotion* 3: 48–67.

responses, the by-products are elevated blood pressure, increased stress levels, disrupted communications, reduction in rapport building and inhibited relationship formation.[52] These byproducts are hardly a recipe for articulate communications and collaborative resource deployment with other agencies!

Another study with similar implications for first responders was one in which subjects were monitored for physiological changes while under stress.[53] Given that first responders are called upon to perform critical thinking in a demanding environment, and that talking over a radio system, monitored by hundreds or thousands of people (over public radio channels monitored on scanning radios, and potentially over media outlets) is similar to giving a speech. Recognition of this situation gives us valuable insight into the physiological limitations placed on people speaking at emergency scenes. The study segmented the stressors placed upon the subject into two categories: a mental arithmetic task and a public speaking task. Those studied showed greater anxiety in giving a speech on short notice, than they did in performing a solo task of adding numbers in their head. A significant difference in all monitored bodily reactions was noted, including:

1. Public speaking triggered higher levels of blood pressure and heart rate than mental arithmetic.
2. Mental arithmetic initially changed from increased cardiac activity to a vascular pattern (the blood vessels adjusted to the increased demand for mental capacity) yet in the public speaking task, the elevated cardiac rate and vascular activation sustained throughout the task.
3. The secretion of cortisol (a hormone regulating the body's reaction to stress) rose significantly during both tasks, but the public speaking component caused the highest secretion.
4. Physiological changes in body chemistry have been associated with negative mood, anxiety, anger, confusion, fatigue, and depression. This matched what the test subjects reported in post-experiment interviews.
5. Significance was noted in the order of task performance: those who did the speech first, then the arithmetic fared better than those who still had deliverance of the speech on their minds. This is significant since emergency responders are similarly thinking through complex decision

52 Ibid.

53 M. Al'Absi, S Bongard, T Buchanan, G. A. Pincomb, J. Licinio, W. R. Lovallo, "Cardiovascular and Neuroendocrine Adjustment to Public Speaking and Mental Arithmetic Stressors," *Psychophysiology* (May 1997), 266-75.

> matrixes, receiving input from a variety of sources, and contemplating what to say over the radio, for undetermined and often extended periods of time.

The bottom-line for first responders attempting to control an incident is they will be operating from a position of deficit, at the very time they will need to collaborate with coworkers and subordinates in their own agency, and make the even bigger step toward bridging their efforts with other agencies. This will make efficient operation at the scene of that specific incident challenging, and in a larger context, the dysfunctional working relationships between agencies is likely to languish from month to month, year to year, based upon negative experiences where rapport was lost and trusts damaged during such periods of inhibited communications experiences.

3. Individual Responsibilities

We are likely on the front edge of a trend, during which we will continue to experience a number of communications failures, despite the addition of so much equipment, and we will then turn to a procedural focus based on individual competencies.

As we quietly passed the tenth anniversary of the rescue of U.S. Air Force Captain Scott O'Grady, who was shot down over hostile territory in Bosnia, in 1995, we are reminded of the possibilities regarding better utilization of our communications assets, especially at a time of expanded homeland security missions.[54] O'Grady coordinated his own rescue by hiding from the enemy for six days and by expertly using his portable radio. With technology integrated into many aspects of the first responders' workplace, we have to remain mindful of the challenges present in becoming a proficient user. Rookie police officers and firefighters typically receive minimal or no training on the full and proper use of their radio equipment, yet it will become their most frequently used piece of equipment, one in which their personal well being and effectiveness to serve others will be key. Very few first responders would survive in the manner of Air Force Captain O'Grady if they were trapped and had to make their radio last for several days.

Public safety radio users often are not able to do much more than turn the power on, adjust the volume, push to talk, and maybe change a few channels. We must be

54 Kevin Fedarko and Mark Thompson, "All For One," *Time,* June 19, 1995.

mindful of a predictable level of "Blinking 12 syndrome," in which people tend to use only a portion of a technology product's capabilities (like the blinking, unset clock on home video equipment,) instead of reading instruction manuals and experimenting with seldom-used features.[55] The challenge for the future will be to configure radios to be more intuitive to use, while providing more training (and a commensurate level of motivational self-interest,) to the field responders who will need to know how to use their radio as a life-safety device, and during infrequent circumstances, immediately recall how to change to another bank of channels. Most first responders use only a small portion of their portable radio's capabilities— perhaps a primary dispatch channel and a few tactical, on-scene channels. Maneuvering to additional channel banks, where interoperability channels often reside, is a cumbersome process requiring the turning of knobs, and/or manipulation of buttons, pressed in precisely the proper sequence. Many radios also have features allowing access to alternate communications modes, yet that requires knowledge of relative advantages and disadvantages, and the aforementioned ability to reset the radio's selector switches and buttons.[56]

Manipulating portable radio settings is a difficult task to accomplish under ideal conditions; the chance of successful selection of a different channel bank is much more challenging under typically adverse operating conditions. Factors in the operational environment of first responders include:

1. recalling seldom-used information under stress
2. need to converse instantaneously and intuitively
3. environmental factors, such as darkness, cold, rain, etc.
4. protective equipment interfering with dexterity and clear speech (gloves and respirators) and
5. need to pay full attention to critical factors, without focusing on equipment

55 "Blinking 12 Syndrome" is widely used in various forms in technology circles; first use undetermined.

56 Such as "conventional," "trunked," and "repeater" modes; terms associated with how the hand piece accesses a radio system or other hand pieces.

4. Factors Influencing People Experiencing Stress

People within the first responder community can readily identify with a phenomenon that occurs when someone is transmitting on a radio at the scene of a critical incident. The pitch and pace of the person's voice typically and uniquely changes, signaling to the listener that something urgent is being described, regardless of whether the person's voice is recognized, or associated with a particular individual. This condition accounts for the widespread practice of leaving public safety radios on throughout the workday, with the listener having no comprehension of specific content of routine transmissions, yet listeners will instantly be alerted if their radio number is called, and will especially divert their attention, if something critical is being transmitted.

The best example for the layperson is the famous recording of the radio broadcast of the Hindenburg disaster.[57] Although it was over 68 years ago, the voice of the announcer reporting the eyewitness account of the huge explosion of hydrogen gas as the occupied, gigantic German dirigible tried to land in New Jersey is a part of classic radio lore.[58] Considering that the account was actually recorded for broadcast at a later time, (the announcer was from a Chicago radio station), helps to validate that it was a sincere and spontaneous recounting of the emotional event he was seeing, especially as his voice breaks-down while he delivers the classic line, "Oh, the humanity…"

Another, more contemporary example was Walter Cronkite's announcement of the assassination of President Kennedy, his voice cracking with emotion, as he removed

57 Herbert Morrison, The Hindenburg Broadcast, May 6, 1937. http://www.eyewitnesstohistory.com/vohind.htm. (Accessed August 3, 2005).

58 Hindenburg Radio Broadcast Transcript: "It burst into flames! Get out of the way! Get out of the way! It's fire and it's crashing! It's crashing terrible! Oh, my! Get out of the way, please! It's burning, bursting into flames and is falling on the mooring mast, and all the folks agree that this is terrible. This is the worst of the worst catastrophes in the world! Oh, it's crashing...oh, four or five hundred feet into the sky, and it's a terrific crash, ladies and gentlemen. There's smoke, and there's flames, now, and the frame is crashing to the ground, not quite to the mooring mast...Oh, the humanity, and all the passengers screaming around here!" "I told you...I can't even talk to people...around there. It's -- I can't talk, ladies and gentlemen. Honest, it's just laying there, a mass of smoking wreckage, and everybody can hardly breathe and talk...I, I'm sorry. Honest, I can hardly breathe. I'm going to step inside where I cannot see it. …. I -- Listen folks, I'm going to have to stop for a minute, because I've lost my voice...This is the worst thing I've ever witnessed..." http://www.hindenburg.net/index.htm. (Accessed October 23, 2005).

his reading glasses at the end of the message.[59] Considering that Mr. Cronkite earned a prominent place in broadcast history using his voice, under circumstances of intense emotion (war zones, political conventions, and civil strife), it is noteworthy that the circumstances of the Kennedy assassination were overwhelming enough for Cronkite to momentarily lose control of his voice. Recognition of this phenomenon helps us to understand that emergency responders, even the most seasoned and experienced, may be handicapped by their own emotional responses at the scene of major crises.

E. REALITIES FOR PEOPLE WORKING IN CRISIS SITUATIONS

Once the influences affecting first responders are better understood and accepted, emergency trainers and planners are directed to several logical conclusions:

- There will be factors beyond the control of those present at the scene that will impact their ability to use their radios in optimal ways. While training and experience can go a long way toward improving radio practices, intensely critical events, such as people severely injured, dying, awaiting rescue, or actively threatening others should be anticipated, along with the propensity of those involved to be impacted emotionally. While this is admittedly the proverbial "once in a career" occurrence, emotional handicap should be anticipated in dire command circumstances.
- Radio communications during cataclysmic events will not be as expedient or helpful as during lesser emergencies. As described elsewhere in this thesis, people are creatures of habit. We revert to practiced behaviors in times of crisis. Consider that the average first responder is not from busy urban areas like New York or Los Angeles, or Chicago. Out of all of the thousands of responses made daily across the nation, relatively few are truly life and death situations, with lives hanging-in-the-balance, even in busy urban areas. The vast majority of situations are non-critical, in the eyes of the responder, (despite the citizen's perception of crisis due to a stolen car, lost child, or amputated finger).
- During these periods of routine operations, confidence is built-up in using the radio equipment. The user has generally clear air to intersperse conversations to coworkers and dispatchers, having needs met through casual or routine turns of speech between sender and receiver. With the prevailing light radio traffic and with normal emotional states, first

59 "The words stuck in my throat. A sob wanted to replace them. A gulp or two quashed the sob, which metamorphosed into tears forming in the corners of my eyes. I fought back the emotion and regained my professionalism, but it was touch and go there for a few seconds before I could continue." [Sentiments of TV Anchorman Walter Cronkite as he announced the words: "From Dallas, Texas, the flash — apparently official. President Kennedy died at 1 p.m. central standard time — a half hour ago…"]. http://www.tvrundown.com/lostfilm.html. (Accessed on August 24, 2005).

responders are able to conduct efficient business conversations on a daily basis. Nothing in this pattern adequately prepares the user for crisis communications. During periods of high-volume, high-stress crisis situations, the user's expectation and reliance upon good communication continues, but the increased pace and load on the radio system, combined with unique emotional influences present, tends to hamper, rather than facilitate, the process. Much like the general public's expectations of cell phones continuing to meet their communications needs during peak calling periods, numerous post-disaster reports describe the common occurrence of cell phones (which *are* radio units interfaced to the public switched telephone network) failing when they are needed the most.[60]

- Recording of radio channels and their playback during after-action reviews, legal proceedings, and to world-wide audiences on cable television has added additional pressure, increasing the level of "stage fright" a radio system user may feel (unlike those in the private sector and military, public safety radio conversations are subject to public release by open records and freedom of information laws). Much like the replay of a controversial judgment call at a sporting event, incident recordings are frequently replayed over and over and may even factor into promotional decisions and general formation of an opinion of "fitness for command," which is a very fragile commodity in first responder circles.[61] Despite more quantitative and objective measures of fitness for duty and command and the worthiness of being a leader, the traditional and persistent reality is reputations are earned not in the aggregate, during months and years of dedication and competence, but during fleeting moments of snap decisions and impressions created by remote monitoring of emergency scene radio transmissions.

This is not to suggest that people will hesitate in a moment of crisis to vainly contemplate the personal gain that can be attained by sounding competent and in control, but it does suggest that radio transmissions, which are monitored by a large audience, are not as intuitive and spontaneous as a private telephone conversation. Given that a large percentage of the general public is apprehensive and fearful of delivering a speech to a large room of people, even with adequate notice and preparation, consider the challenge

60 "Some of the basic weaknesses exposed by September 11—and, one would have presumed, since fixed--seemed instead to linger. For example, police and other officials were unable to communicate as their cell phones failed and satellite phones took days to arrive." "Unprepared," *Washington Post* [Post-Hurricane Katrina Editorial] September 5, 2005, A30.

61 "Last fall, I listened to the initial attack radio conversations from a fire that ultimately burned significant timber acreage…" "The captain on the engine was at the scene but was hesitant to establish himself as the incident commander. He went so far as to ask the air attack officer orbiting above the fire to assume this role." Michael S. Terwilliger, "Captain In Charge?" *Fire Chief Magazine*, April, 2003. http://firechief.com/news/firefighting_captain_charge/index.html. (Accessed on December 22, 2005).

inherent in verbalizing, (ideally in optimized, unambiguous syntax) a pattern of words containing specifics unknown just minutes prior, and you start to get an appreciation of the moment of hesitation radio users at the scene of disasters experience just prior to pressing the transmit button.

IV. ANALYSIS OF THE CLASSIC APPROACH

A. METHODOLOGY

Since true disaster-level emergencies happen so infrequently, it is important to utilize periodic exercises and careful evaluation to provide proof of concept. Outcomes can be measured during training exercises, to provide a valuable notion of areas needing improvement. As was described in Section III, the U.S. Military has made productive use of simulation training to improve the performance of crews operating under similarly stressful conditions.

Metrics obtained through radio system loading data provide confirmation or counterpoint to anecdotal experiences reported by participants in routine training exercises. Decidedly less scientific, but nonetheless valuable, are comments gleaned from after-action reviews, during which communications issues are frequently delineated. Further opportunity to quantify improvement efforts can be accomplished by post-incident transcript reviews, during which the effectiveness of communications can be rated. With a stated objective of emergency communications being the timely and effective delivery of a message, efficiencies in each speech turn (communication exchange) can be scored, based on specific criteria. Scoring criteria may include: successful message delivery, economy of wording to deliver the same content, and number of times a message went unacknowledged, or number of times it was necessary for a message to be repeated. A subjective assessment of the sender's excitement level can also be assessed as a diagnostic tool to evaluate the impact on communications effectiveness.

B. NATIONWIDE CASE STUDIES

1. New Hampshire

In 1997, the New Hampshire State Police faced a rolling shooting rampage by a begrudged citizen with an assault rifle, resulting in the deaths of two law enforcement officers, a judge, and a newspaper editor. After he stole a police car, retrieved additional ammunition and altered his appearance, many agencies responded, including local,

county, state, and federal law officials.[62] A series of radio communications failures were attributed to incompatible radio systems and failure of portable radios in fringe reception areas. However, one of the officers involved confirmed that having a working radio unit doesn't guarantee effective communication in a crisis. "Trooper West, encountering problems with static and having difficulty raising the command post on his portable, ran back to the parked cruisers to attempt to use a cruiser radio. 'There was so much (radio) traffic because of the police responding (to the scene) that I couldn't get air time to talk to our dispatcher. So I gave up trying to communicate with anybody at [that] point.'"[63]

This is a common complaint-- even though the radio system remained operational, the volume of radio traffic creates communications bottlenecks, leading to frequent, "couldn't get on the air" comments. Radio discipline by all systems users, limiting conversations to those absolutely necessary, is a must, in the interest of operational efficiency.

2. California

The California Fire Service is renowned for their ability to handle large groups of responders mustered for their perennial wildland fires. One such fire in Southern California in 1993, resulted in the response of hundreds of pieces of fire equipment, manned by thousands of personnel.[64] "Firefighters from other California communities, the U.S. Forest Service, local law enforcement and the California Highway Patrol, emergency medical service staff, the American Red Cross, the Salvation Army, Los Angeles County Parks and Recreation, utility companies, railroad and transportation representatives, civilian volunteers and the news media were all involved. L.A. County has two VHF channels that are used in tactical situations. Protocol calls for fire ground communications to switch to one of the VHF channels as soon as the first responders arrive on scene.[65] This tactical radio channel can quickly become overloaded as the

62 Donald A. Lund, "The Lessons of Non-Interoperability in Public Safety Communication Systems, The ATLAS Project, Advanced Technology in Law And Society," University of New Hampshire, Benchmarks and Blueprints, April 2002.

63 Ibid, with citation of Department of Justice, Immigration and Naturalization Service Film, "The Colebrook Incident," film dialogue.

64 Ibid.

65 Very High Frequencies (VHF) operate in the mid-range of all public safety frequency spectrums, providing a balance of long distance reach and in-building coverage. Generally operated with multiple units able to talk and listen on the same frequency.

number of firefighters and their geographical separation from the incident commander increases. As the fire grew out of control and both channels became increasingly overloaded, 'communications discipline completely broke down' which further interfered with interoperability.[66] 'In addition, the State of California had licensed three VHF channels, referred to as 'White One, White Two, and White Three,' for fire mutual aid state wide. All fire apparatus in the State was to be equipped with radios operating on these frequencies. However, some fire departments were no longer equipped with VHF radios, and some others changed the names of the channels. The lack of standard procedures (nomenclature) further hampered over-the-air interoperability."[67]

Establishing common interoperability channels is a frequently used strategy to enable communications between agencies. This use of common channels can be effective, but this case typifies the tendency to allow such contingencies to become ineffective through lack of maintenance. Local jurisdictions need to enter into common governance agreements and task people to assure compliance and preparedness. While instantaneous interoperability is provided, it will be critical to manage the flow and volume of radio traffic through end-user, point of source, radio traffic management techniques.

3. Texas Case Study from a Regional Fire Training Exercise in October 2005

Modeled after the U.S. Navy TADMUS air warfare decision making experiments described in Section III, the thesis author conducted a study in the fall of 2005, involving coding communications from a series of training exercises in the suburban cities north of Dallas, Texas. The specific purpose of the exercises was to practice working with other agencies, through a scripted series of actions to be taken at the scene of a simulated multiple-alarm structure fire. The exercises were held at a training academy where facilities allow for burning of straw and special effect lighting to create realistic building fire conditions. While the participants were focused on tactics and accomplishment of operational objectives, this case study enabled analysis of the communications conducted toward those goals. This is especially significant in validating the findings since the

66 Public Safety Wireless Advisory Committee, Interoperability White Paper, April, 1996, 3-4.10.

67 Final Report of the Public Safety Wireless Advisory Committee, September 11, 1996, Appendix A, 3.

participants weren't knowingly engaging in a study on communications, but rather using radios as they normally would at a building fire, with several separate agencies working together.

The goal for this study was to measure the quality of first responder communications to determine where improvements in communications can be made. Table 1 presents a description of the types of units participating in the training exercise, along with metrics relating to the communications conducted during the exercise. Table 2 present results of the communications coding analysis.

Number of Fire Departments Participating	5
Number of Engine Companies	6
Number of Truck Companies (or Engines w/Elevated Streams)	5
Medical Units (Ambulances)	2
Duration of the Exercise in Minutes	62
Number of Communications Turns	428
Average Length of Each Message in Seconds	7
Number of Words Broadcast	3556
Average Number of Words Per Communications Turn	8
Average Number of Words per Minute	57

Table 1. Training Exercise

Participants were from a number of surrounding career departments, deployed in two-to-four person teams on engines, ladder trucks and medical units. This exercise was typical of others in the multi-week series, insomuch as there were 13 units, totaling about 50 firefighters and command officers. Each participant was provided with a portable radio on a common channel, with the incident commander and an aide seated in a command car (a sport utility vehicle), operating on a mobile radio.

4. Evaluation Methodology

The thesis author obtained a recording of the radio transmissions occurring during the exercise, from which a written transcript was produced. This provided the basis for scoring the communications conducted.[68] Notations were made and tabulated for:

68 Included in Appendix A.

1. Instances in which the message was not received or was unclear and had to be repeated.
2. A subjective assessment rating of the excitement level of the voice (either normal, or excited).
3. Use of any codes or phases other than "plain English."
4. A subjective assessment rating on whether the message was critical to operational picture development and/or tactical efficiency, or whether another method could have been employed.

5. Findings

% of Turns	# of Turns	Anomaly Type
11.9%	51	Unacknowledged Message
4.9%	21	Needed to be Repeated
2.6%	11	Confused/Unclear/Questionable Value
1.2%	5	Exclamatory/Excited Message

Table 2. Communications Anomaly Analysis Summary

The percentage of messages needing to be repeated was 4.9%; plus 11.9% of the radio messages were unacknowledged (33 out of the 51 unacknowledged messages were to the incident commander), and were presumed to be unheard. In addition, 2.6% of the communications turns were judged to be a questionable use of radio airtime, e.g. face-to-face message exchange may have been more appropriate, instances of redundant information communicated, or information of questionable value transmitted. The collective total of repeated, unacknowledged, and questionable communications turns equaled 19.4% of all messages, indicating a significant opportunity to reclaim nearly one-fifth of all radio airtime lost to such inefficiencies.

It should be noted that a few of the repeated messages occurred because personnel were trying to talk while wearing an airpack facepiece. Interference caused by the airpack facepiece has been an area of concern for many years, with only marginal success in

technological improvement.[69] This was not a major contributing factor, since the messages were discernable on the recordings reviewed.

One way to improve the communications efficiency rating would be to provide training on better prioritization of radio messages and introduction of the concept of communication alternatives, other than public safety radio. Face-to-face communication and sector-level task coordination are examples of ways to achieve objectives without use of radio resources.

The presence of unacknowledged messages to the incident commander is an area of concern, and was noted in other un-scored exercises in this series, as well as the recordings studied from actual emergencies. Further research is needed to fully assess predominant reasons for such inattention, since radio problems and clarity of the message were not noted on the recording. The incident commander was presumably attending to something else at that instant.

It would be beneficial to assign personnel at the emergency scene exclusively to facilitate communications support for the incident commander. Some large first responder departments have such scene-based communications capabilities (aides, chiefs' drivers, etc). Other agencies should seek creative ways to develop such expertise, perhaps detailing first-arriving support personnel (who often self-dispatch to large-scale incidents). Greater operational efficiency, enhanced crew safety, and "reclamation" of scarce radio airtime can be expected if communications support personnel operate inside a quiet environment, at the command post, with the incident commander. Communications specialists should be supplied with adjunct devices, such as headphones and visual displays, allowing them to pay close attention to radio traffic and assist the incident commander in communications continuity.

To the credit of the departments involved, the use of non-standard codes was not noted in the exercise studied. The only code used was "10-4," which is universally recognized as meaning a message has been received. Use of codes and phrases not

69 Greater attention is needed to the issue of responder communications while wearing respirator facepieces. Many agencies with limited experience in communicating while using respirator facepieces, especially in law enforcement, have issued respirators to their personnel, using homeland security grants. Extensive training and exercises should be provided for people new to operating with such equipment, prior to entry into hazardous environments.

understood by all was a concern at other, non-scored, exercises in the series, leading to renewed examination of “plain English” policies. (See Section V.B.4 for additional discussion on the need for plain English during joint operations.)

Observation of the participants in this regional fire training exercise revealed they were able to successfully maneuver their portable radios to the proper common operational platform, with spare radios supplied to those without compatible radios. It is significant, however, that the users were coached and prompted on how to set their radios, during a pre-exercise briefing, in well-lit, supportive surroundings. While it was encouraging to see such adaptability and inclusion of radio orientation is an appropriate component of any such mutual aid exercise, it can be expected to need regular reinforcement and will likely be more difficult to accomplish under stress, low lighting conditions, and at the peak of operational demands. A strong case for radio orientation and communications checks, as a part of the staging-area process, was made by this observation.

The Incident Commander conducted a roll-call, upon abandoning interior operations, after being on-scene for about 34 minutes. The process, known as Personnel Accountability Report (PAR), involves individually calling each unit’s command officer for a verification of crew safety. The process consumed 33 communications turns, using over five minutes of airtime. Anything that can be done to automate this process, such as technological aids, would allow for near-instantaneous information, without the need to call each unit individually. A positive aspect was noted, however, in that the communications following the PAR process were more orderly and did not have the number of unacknowledged and repeated communications turns, immediately preceding the evacuation of the structure. The PAR process affords a rare “time out” from tactical operations and resulted in reestablishment of efficient communications flow. Incident commanders would be well-advised to call for a “regrouping” if radio channel traffic becomes disorderly.

Further evidence of the need and challenge to optimize every word for maximum clarity and unambiguous syntax was revealed in the relatively rapid and clipped pace of chatter—the average was eight words per transmission, at a rate of 57 words per minute (nearly one word per second).

Another caveat to consider when assessing these results is to remember this was just a training exercise. The participants had general foreknowledge of what was to occur and while some risk was associated with the creation of a minimally hazardous environment, with real smoke, there was not the added urgency of people awaiting rescue, yelling for help, risk of secondary anti-personnel devices, or compromising of the building's structural integrity in this controlled environment, compared to the real thing. Yet despite these favorable factors, an element of emotional excitement, attributable to many of the same factors that would be present at an actual incident, were noted. In five of the 428 communications turns studied, the message was delivered with a measure of excitement in the voice, including, "…Stop," "All units, hold your traffic, stand by…," "… a lot of heat and smoke," and "…going to withdraw!" These messages were consistent with those noted in other, actual incidents, but they did not contribute to an escalation of the excitement level of other users (as sometimes is the case,) perhaps because it was a training exercise, with only a minimal hazardous environment present. It should be anticipated that the pace and depth of the systemic weaknesses would be greater under actual emergency situations.

6. New York

In the summer of 2005, the New York City Fire Department (FDNY) was compelled by court order to release 900 minutes of radio recordings between dispatchers and fire and emergency medical service personnel from the terrorist attacks of September 11, 2001. While the 9/11 Commission Report goes into extensive detail on the lapses of communications on that day, both intra- and extra-departmentally, a complete auditory review of the entire series of tapes revealed additional emotional components which did not always come through in written transcripts.[70] The report cites both technological and "business practice" influences as causal factors in the communications breakdown.

70 National Commission on Terrorist Attacks, 2004.

The FDNY has the most robust response capability to respond to major incidents, and indeed had a greater depth of experience in dealing with urban disasters than any department in the United States. Although the methods and procedures that had become tried and true over the years largely failed them on that day, the factors leading to the communications failures were strikingly similar to other nationwide incidents studied.

The subject of first responder radio communications in New York City in general, and on 9/11 in particular, would take a thesis unto itself to adequately describe and do the subject justice. Perhaps that is why some of the discussions about radio practices conducted by the 9/11 Commission seemed, by some, to be myopic and misdirected.[71] It is a complex and difficult discussion to have in sound bites and a sentence or two where several pages would be necessary to adequately describe all of the factors.

A series of excerpts is included in this section to provide the reader with a flavor of what occurred that day; these excerpts were carefully selected to prove a point, i.e., that there are predictable communications failures during emergencies, attributable to specific factors. This edited version does not paint a complete picture of the many heroic, competent, and effective communications first responders initiated that day.

It is appropriate to recognize that some of the voices contained on these tapes were either of those who later lost their lives in the heroic effort, or were making reference to those who did. As such, they are reviewed and treated with an appropriate measure of respect and honor. Any criticisms made, which may directly or inadvertently implicate any individual who later became a casualty, is meant only in the spirit of process improvement for future teams facing similarly cataclysmic circumstances, and is not meant in any way to diminish their sacrifice, especially considering that they were applying widely accepted department practices of that era.

71 National Commission on Terrorist Attacks, 2004.

Selected radio transmissions,

New York City Emergency Medical Service (EMS) and

Fire Department (FDNY) Personnel

on September 11, 2005:[72]

Comments by the thesis author are included in [brackets].

[Units have already responded to the initial reports of a plane crashed into one of the World Trade Center towers.]

9:18 a.m.

Caller to EMS Central Dispatch: I'm inside the subway station on the corner of Vesey and Church. I have three aided downstairs, two females, one male that needed to be transported ... This is horrible.

[Specific information superfluous with so many injured; emotional utterance heightens tension. Better to establish triage/treatment/transport sectors.]

9:34 a.m.

Call to EMS dispatcher: 12 Charlie. Be advised I have seven ambulances, seven ambulances no bosses sitting on West Street and Vesey Street, West and Vesey. We have no bosses, seven ambulances and no idea what to do.

[Command lapse creates need to call for orders, using valuable airtime.]

9:42 a.m.

Manhattan FDNY Dispatcher: Manhattan calling Fieldcom with an urgent.

Field Communications Unit [Fieldcom]: Proceed. Manhattan-Fieldcom.

72 Newsday, Inc., "Audio: Dramatic Radio Transmissions from September 11," August 22, 2005.

Dispatcher: All right. Male hanging from a window near the antenna on Building One [One World Trade Center, or north tower]. That would be on the top floor. OK.

[Use of the word “urgent” was helpful to command attention and should be used whenever appropriate; dramatic message increases tension.]

9:46 a.m.

Fieldcom calling Manhattan. On the 80th floor, northwest corner, 50 people trapped. That's in Building One.

[One of many situational updates for command from callers to 911. Opportunity to handle via data transfer from 911 to incident commanders at the scene would be helpful and would make more airtime available.]

***

FDNY Dispatcher: OK, Fieldcom, 104th floor northwest corner, 50 people trapped. The fire's burning beneath them.

[Added urgency to an already critical situation.]

Fieldcom: What building?

Dispatcher: That's Building One.

Unidentified: (inaudible) ... three to Manhattan, urgent. One of the buildings is partially collapsed... the area...

[Clipped phrases caused by the radio cutting in and out convey limited operational picture.]

Dispatcher: Identify yourself.

Unidentified: (inaudible) ... three. A major collapse in one of the towers.

[Difficulty in authenticating caller and pin-pointing location.]

Dispatcher: Which tower?

Unidentified: Tower Two. [2 WTC, or south tower.]

9:49 a.m.

Unidentified Firefighter: Tommy, have you made it back down to the lobby?

Tommy: The elevator's screwed up.

Firefighter: You can't move it?

Tommy: I don't want to get stuck in the shaft.

Firefighter: All right, Tommy. It's imperative that you try to get down to the lobby command post and some people up to 40. We got injured people up here on 70. If you make it to the lobby command post, see if they can somehow get the elevators past the 40th floor. We got people injured all the way up here.

[Individual tactical discussions between two persons cannot be supported when dozens of people are assigned to the same radio frequency, and higher priority communications needs exist. Such would be entirely appropriate at routine incidents, but inefficient when multiple urgent situations are occurring.]

9:59 a.m.

Tower Two collapses as the citywide dispatcher tries to reach the command post on the radio.

Dispatcher: Box 8084 [refers to commanders assigned to the incident], what is the command post? Box 8084 (clicking, then silence)

Dispatcher: I need the location of the command post.

[Loss of continuity of communications with command—positioning of command post away from immediate area would increase likelihood of continuous command.]

Unknown voice (yelling): Explosion!

[Unidentified reports from individuals clouds accurate command and control—ideally the same command officer should be giving overall situational updates.]

Dispatcher: Car 65 command post is Church and Fulton, Church and Fulton.

Unknown voice: Citywide, the tower just collapsed.

Unknown voice: Citywide, be advised the tower was (garbled).

Dispatcher: Everybody just standby, standby! [Dispatcher attempts to untangle overlapping radio reports.]

9:59 a.m.

Two World Trade Center, south tower, collapses.

Marine [Boat] 6: Marine 6 to Manhattan.

Dispatcher: Manhattan to Fieldcom.

Marine [Boat] 6: Marine 6 to Manhattan. Urgent. Tower Two has had a major explosion and what appears to be a complete collapse...

[Better-quality information from a unit at a detached position of perspective; emotional control of voice lends authentication to the message.]

10:01 a.m.

8Adam: We're responding down to the MCI [Mass Casualty Incident].

Manhattan Central Emergency Medical Dispatcher: Negative, negative, I need you for something else.

[Dispatcher is trying to attend to other medical emergencies in the rest of the city. “Self-dispatching” is a common feature at large-scale incidents, leading to a loss of tactical resource deployment and potential targets for secondary attack.]

8Adam: The tower [2 World Trade Center, south tower] has collapsed. The tower has collapsed.

10:04 a.m.

Unknown voice to dispatcher: I'm on West Side Highway, I'm at cross street to Wall Street. I've got FD personnel down, I got EMS personnel down, dispatchers and so forth. I have debris all over my vehicle. I cannot move at this time.

[Unidentified, yet helpful in its descriptiveness]

Dispatcher: All right, 10-4, 10-4.

Unknown voice: Supervisor, I have a fireman who was caught here in the explosion live over here severely injured.

(Sound of someone gasping, then silence)

[Injured comrades increases anxiety levels]

10:05 a.m.

Unknown caller to dispatcher: The former staging area at Vesey and West is no longer usable. (garbled) set up a staging at Vesey and North End.

Unknown caller: What is the best access to the staging?

Dispatcher: No best access at this time, there is no best access.

10:07 a.m.

NYPD Aviation unit says 1 World Trade Center, north tower, is leaning and in danger of collapse.

07 NORA: There was some sort of explosion. Half of the crews are unaccounted for... 1 World Trade.

10:12 a.m.

Unknown caller to EMS dispatcher: We're right in front of the building that collapsed at the Trade Center. I'm stuck with a patient here who has possibly a broken hip. I need some help if anybody can get over here possibly.

[Single victim among hundreds awaiting assistance; ineffective use of limited airtime, given the scope of what was occurring.]

Dispatcher, frustrated: Sir, we have numerous people trapped at this time, numerous priorities. The first unit available will be sent to you.

10:19 a.m.

22Adam: (alarmed) Can you assist me with the ... I am on scene. I am Albany Street and South End Avenue.

Numerous fire, PVs, and ambulance on hand with me. We have no idea where we're going. Where is the safe area?

[Individual command issues, instead of staging and sector control]

Manhattan Emergency Medical Dispatcher: All right 22Adam, Vesey and where?

22Adam: 22Adam, Albany street, Albany Street and South End Avenue.

[Message repeating]

EMS Dispatcher: 22Adam, calm down.

22Adam: I have to yell, I can't everything.

[Emotional component in voice degrades communications]

Unidentified: ... off so we can hear him.

EMS Dispatcher: It's Vesey and Chambers.

22Adam, if you're going to be like this on the air you need to stay off.

[Tension leads to rude communications turn]

10:27 a.m.

Manhattan Central Emergency Medical Dispatcher: 32X, go, where are you?

32X: We got a four ... That one has third-degree burns throughout his face. I'm gonna go to St. Vinnie's [St. Vincent's Hospital] with all four …, is that OK? There's no conditions for us here.

[Individual hospital requests demand too much airtime. Instead, a system of triage, treatment, standing orders utilization and silent transport will conserve airtime.]

10:28 a.m.

1 World Trade Center, north tower, collapses.

10:30 a.m.

Firefighter: Call to Command Post Manhattan South. Me and my partner are both OK ... We have building collapse. We have total blackness ... .we have no visibility. We have no way to get out of here ... Charlie to Central: Mayday.

[Emotional component of message indicating comrade is in immediate danger and needs rescue; incomplete information frustrates dispatchers and commanders.]

Mobile Command Center: The other tower has collapsed. Major collapse. Major collapse

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Marine Boat 3: Everybody get out, we had a collapse of the second tower ... All units, we have received a report that No. 1 and No. 2 World Trade Center have collapsed -- both towers.

[Clearest operational picture conveyed from detached position of perspective from the waterfront a few blocks away.]

***

Battalion 26: We are at Broadway and Vesey. A huge dust cloud, people are all around.

* **

Dispatcher: Manhattan to Division 11.

(Silence).

Dispatcher: Any other unit for Manhattan.

(Silence).

FDNY Dispatcher: Manhattan to Fieldcom.

[No answer—a bad sign—very unusual occurrence when radios are still working]

Unidentified Firefighter: George, have them mobilize the Army. We need the Army in Manhattan.

[Never before said, heard, or contemplated in fire department operations, to be sure. Sender conveys a frantic tone in his voice.]

FDNY Dispatcher: All units stand by. Everyone try to calm down. Manhattan to Fieldcom.

[Dispatcher works to reassure in the face of multiple crisis communications.]

(Silence)

FDNY Dispatcher: Manhattan to - Manhattan to -- Manhattan to Car 9. Urgent. Manhattan to Car 9. Urgent.

(Silence)

All right. Manhattan to any unit operating at the fifth alarm West Street, at Liberty Street, at Tower No. 2. Any unit. Any unit operating at No. 2 World Trade Center at the collapse. Contact Manhattan by radio forthwith.

FDNY Dispatcher: OK, Car 33 Bravo, we understand there was some kind of major collapse. Can you report?

Emergency Medical Service worker: This is an EMS worker. There's been a major collapse. We need additional units forthwith.

[As no command staff answers, dispatcher seeks anyone to answer.]

***

07Nora: Several of the crews are unaccounted for. We had two units on the scene and we had a Jeep on the scene. Half of the crew is unaccounted for. Visibility is bad.

Manhattan Central Emergency Medical Dispatcher: Are you saying that these people are involved? EMS involved?

07Nora: ... (unintelligible)

[Among the many unclear communications turns]

Dispatcher: OK, 7Nora. 10-5 [repeat] your message. You're saying because of the tower collapse, the captain was involved in this?

7Nora: 10-4. We're setting up a... (GARBLED)... are falling.

(Silence)

[Ineffective, clipped phrasing]

Dispatcher: Can I have an identification?

(Silence)

***

10:31 am

A civilian voice.

Unidentified Civilian: (shouting) Can anybody hear me. I'm a civilian. I'm trapped inside one of your fire trucks underneath a collapse that just happened.

FDNY Dispatcher: Stand by, there's somebody close to you.

Civilian: I can't breathe much longer. Please save me. I'm in the cab of your truck.

FDNY Dispatcher: OK, person transmitting the Mayday. Where are you?

Civilian: I just told you. If you look at the World Trade Center, there's the north pedestrian bridge. I think it just collapsed ... I was on the street. I don't have much air. Please help me.

Firefighter: I copy that, I'm going to go look for him.

Civilian: I can barely breathe, please send somebody.

FDNY Dispatcher: OK, person calling for help. Listen to me. You need to calm down and relax. Stand by. We do have somebody on the way. Maintain air. Get off the air. We do have somebody on the way over to you. You are to remain calm. 10-4?

Civilian: I'm in the cab of a truck.

[Also unprecedented- increases an already tense situation]

FDNY Dispatcher: Manhattan to any unit at World Trade Center 2. Urgent. EMS Ladder 15, I want you to go to the nearest chief, fire department chief, and have him come to the radio forthwith. If you find anybody with a white hat, get him to come to the radio. I need a report to find out what else I can send to him ... Let me know who is in command there at this moment.

[Dispatcher desperately attempts to restructure command and control, from his remote location.]

11:10 a.m.

At the scene, trapped firefighters begin to radio for help.

Firefighter: I'm trapped here

FDNY Dispatcher: Rear of tower of number one?

Dispatcher: There is help on the way. Calling any unit to assist the trapped firefighters.

FDNY Dispatcher: Calling any members to assist trapped firefighters...

11:18 a.m.

FDNY Dispatcher: I have a trapped firefighter --

Firefighter: Chief V -- is trapped, I have him... I need some help getting him out --

FDNY Dispatcher: We have some units coming, we are coming in a city bus.

11:31 a.m.

In the aftermath of the towers' collapse, confusion reigns in lower Manhattan.

FDNY Dispatcher: All units, a report of a bomb in the Brooklyn Battery Tunnel.

FDNY Dispatcher: We have a number of city buses at the Brooklyn bridge [filled with firefighters].

FDNY Dispatcher: Calling Capt. V.? Come in, Captain V. if you hear me? Calling the unit looking for Capt. V.?

[Multiple, unrelated conversations invite inappropriate assumptions]

(Confusion)

FDNY Dispatcher: I'm getting four different chiefs giving me four command posts. I have Park and Vesey, West and …

Chambers, Liberty Command, and Church Command. You guys have to help me out, here.

FDNY Dispatcher: All units -- calling Captain V. -- come in if you read me...

(end of published summary)

In the hours following, command and communications were reestablished at the largest, most difficult rescue and recovery operation ever conducted in urban America. While the radio equipment itself and all forms of communications between the fire and police departments were extensively questioned in the months and years following, the preceding selected radio transmissions indicate a need for changes to radio procedures. Changes to radio procedures are needed to:

1. Manage and reduce the amount of radio transmissions.
2. Establish procedures and policies for treatment of large numbers of casualties without the need to call for help individually for each one.
3. Command and control from a detached perspective aids in the quality of the information provided and in the vocal emotional control of those transmitting.

C. HOMELAND SECURITY GRANT FOCUS

In the immediate aftermath of 9/11, many officials reported communications issues between responders within the same department and with other agencies. These all struck a familiar chord since many of the same things were said after the Oklahoma City Bombing and Columbine school shooting, in addition to numerous incidents of regional significance around the country.

Since that time, interoperability has arisen as a top grant funding priority. The rush to address the issue has made it all too easy for agencies to select equipment without much thought or due diligence.

Immediately following 9/11, homeland security funds were first distributed in the manner we were most familiar with, i.e. “pork barrel” spending methodology. The distribution methods vacillated between one extreme where the most politically powerful were able to bring money to their home districts, and the other extreme where an equal distribution method resulted in an attempt to evenly distribute grant money to every state, which produced uneven per-capita expenditures in places where risk seemed remote. To answer the charges that a risk-based formula should be used, the Urban Area Security Initiative (UASI) funding system was devised in 2003 to skew the resource distribution toward the highest density of U.S. urban areas.

In the short history of homeland security grant funding, we have experienced a unique pressure to make quantum improvements in our homeland security posture, literally “before the next attack.” The immediacy of the moment encouraged a process in which jurisdictions were under extreme time constraints to submit grant applications or risk the appearance and actuality of not getting money for the local effort, in competition with other cities nationwide. The tendency was to cursorily scan the “menu” of equipment available in standardized grant request forms, quickly make a choice (which

generically would be identified as something like, “interoperability equipment”), and get the verbiage and justification prepared in a short time span, before the arrival of immediate, inflexible deadlines. Then a few months would typically pass, and if approved the radio patching equipment would arrive, without much forethought on how it would be used, who would operate it, any potential security vulnerability it may create, and any deleterious effect it may have on communications networks.

In essence, the cost of such equipment previously drove agencies to a deliberate process of alternative evaluations and careful selection based on operational needs. In the years since 9/11, it not only is easier to access the funds, but the process itself has encouraged haphazard requests for radio interconnection equipment and resulted in the development of unrealistic expectations.

The expedited process has fostered a very real concern regarding the effect such equipment will have on the disaster operations of the future. While the equipment does hold the potential to improve emergency scene communications, improved communications will only result if the new equipment is deployed properly and if the users modify their radio habits. The likely outcome of having only a superficial appreciation of what the equipment operator is doing, and continuance of overly-chatty radio turns, will hasten the collapse of communications networks (due to overload), instead of producing the intended outcome of improving the quality and capacity of emergency communications.

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V. CREATIVE SOLUTIONS – A BETTER WAY

A. PROCEDURAL MODIFICATION

It is a truism of human nature that people revert, in times of crisis, to what is familiar and practiced. As the "fight or flight" survival mechanism kicks in, the brain has a lot to do on behalf of the host: chemically regroup the body so major muscle groups are ready for immediate action, process multiple sensory input, make quick sense of some things, entirely ignoring other information. The most well-intentioned plans and procedures can look very good on paper and fail to translate into valuable guidance during times of crisis, unless the limitations of the human physical and cognitive functions are considered.

The intention of this section is to anticipate the companion behavioral components of radio interoperability, divert the dominant focus from technology, and devise a template for agencies interested in optimizing their mission-critical communications. In doing so, the result will be better, more realistic expectations, and more effective communications within the limits of public safety radio infrastructure. These strategies will likely gain widespread acceptance only after a series of practical failures continue, despite the expenditure of so much homeland security grant money to achieve "interoperability." Proactive agencies have an opportunity now to be early adopters of procedural adaptation and will avoid inevitable failures of those relying exclusively upon a hardware solution.

1. New Paradigm

Consistent with the principles articulated in this thesis, a set of new procedures were drafted for the first responder agencies at the author's city. The city of Plano, Texas, is adjacent to the city of Dallas and is the home to 250,000 people. A separate department, Public Safety Communications, is responsible for the receipt of 911 calls and dispatching of the police, fire and medical units. The department also operates the radio infrastructure for seven growing cities, over 250 square miles.

As is the case with many public agencies, equipment purchased with homeland security grants has begun to arrive from a number of sources. Little has been said about how to use it: the assumption has been that interoperability starts as soon as the boxes are opened.

To overcome the inherent limitations of radio system patching of multiple units onto a common operational platform, a new procedure is proposed which prioritizes the use of limited radio resources, by controlling the flow at the source. After review of numerous critical incidents involving various combinations of fire, police, medical, local, and mutual aid units, responding to single and multi-jurisdictional incidents, a common pattern of influences was noted:

1. Responding units tended to stop at the first injured person encountered at the periphery of the incident and call for an ambulance to that specific location, even when it was obvious that a mass casualty incident was underway, involving dozens, or even hundreds of victims.
2. Turns of communications became clipped into ineffective bits, to the point where it was difficult to tell who was talking to whom.
3. If a field unit expressed excitement in their voice, the dispatcher's voice tended to also rise in pitch and pace, but not to the full extent of the field users'. The dispatcher plays a key roll in keeping everyone calm by the use of a controlled voice inflection and in exuding a stoic confidence.
4. Units prefacing their transmissions with key words, such as "urgent" "priority message" or "emergency traffic," got greater attention than those continuing to talk unacknowledged and without preface, even if they conveyed urgency in the pitch and pace of their speech.
5. Many incidents eventually got to the point where dispatchers and incident commanders tried to control and reduce the volume of radio traffic by who was talking. Requests such as "all units stand-by" and "command officers only on this channel," were commonly heard.
6. A relatively small number of units dominated a majority of the airtime, often with non-critical matters, while many units said nothing. The channel-loading was unevenly skewed to a small portion of those present.

7. The most assiduous dispatchers and commanders tried to anticipate those things the field users might ask, and act to broadcast a summary of information, before it is asked for, in an effort to preempt use of the radio channel for repetitious information requests. This includes best access routes, staging areas, triage points, command post locations, and brief situational updates. This relatively small menu of variables made up a disproportionate number of repetitious and superfluous radio transmissions.

8. The use of timed milestone updates gave the most even flow of information, acknowledging that time often gets out of phase—either faster or slower, to the perception of those involved at the scene. Many dispatch computer systems have automated features to trigger prompts to the dispatcher at timed intervals, i.e. every ten or 20 minutes. Dispatcher-initiated requests for updates from incident commanders, at timed-intervals, aids in development of an operational picture for those at the scene, as well as for support players off-site (still responding, or at alternate locations, such as Emergency Operations Centers).

9. Listening to recordings after an incident readily allows for identification of inappropriate assumptions and ineffective ("not what was meant,") communications, and unacknowledged speech turns not evident to those involved at the moment. This can be attributed to the calm environment the reviewers are in and the lack of multi-sensorial stimuli imposed upon those performing as the incident was actually occurring. While it is not possible to eliminate all distractions and simultaneous demands placed upon those operating at emergency scenes, the inference here is great value would be derived if sensory input was managed and limited.

2. New Procedure Proposed

As a result of reviewing numerous recordings of critical incidents, it is apparent that the best practice would involve modification of radio system utilization, at the source, to optimize the quality of communications occurring to produce "better" not "more" communications turns.

To answer this need, a new procedure was devised by the thesis author whereby field units will modify their utilization of the system, once declaration of a "critical incident" is made. This is not necessary for a routine building fire or bank robbery, but once a critical mass of units start arriving at an intense incident, such as would be the case at a terrorist attack, it would be invoked to prioritize radio traffic.

The policy draft presented to the Plano Fire Department, by the thesis author, reads in part:

A. It must be recognized that significant single or multiple events can create a communications system overload situation that negatively impacts scene operations. The expected, and understandable, emotional state of radio system users, combined with the shear number of units transmitting on a system, will frequently contribute to a disaster scene communications breakdown. There has been a tendency by some agencies to fragment operational groups at the same incident, onto different radio system talk-paths (talkgroups, channels, frequencies). While assigning additional talkgroups to sectorized functions provides some buffering, it must be remembered that it will become difficult for dispatchers and incident commanders to effectively monitor and control multiple talkgroups. Moreover, there is a practical limit to the number of simultaneous conversations possible on systems that typically are shared by several agencies, and routine radio traffic, will continue, in addition to the specific incident.

Such a "less is more" posture, involving radio system use, runs counter to the policies practiced in daily response to routine incidents. All members must make a conscious effort at disaster scenes to resist the habits practiced in normal operations and limit their use of the radio system to the highest priority of life safety needs.

1. Effective communication between dispatch and the incident commander must be the highest priority, based on the need to properly report size-up (initial appraisal of the scene), operational picture, and requests for additional resources.

a. To that end, dispatch will initiate a *Priority Dispatch Policy* whenever an intensive incident is underway and channel capacity issues are hampering effective communications:

- Dispatch will announce, "the Priority Dispatch Policy is now in effect"
- A periodic, soft beeping tone will automatically be played on the channel as a reminder of the special condition.
- Dispatch will answer with, "(Unit #) go ahead with priority traffic."
- Units operating on the channel will suspend routine traffic (calling en route, requesting assignments, repeating size-ups, etc). To support this step, dispatch will endeavor to broadcast (and periodically repeat) staging area locations, known hazards, triage area, and best access information.

- Calling dispatch on the phone should be avoided since the incident itself is likely to stretch 911 Center capacity. The computer system should be used to achieve silent unit status change notification.

2. Unit-to-unit traffic must be reduced, condensed and prioritized, in the interest of system capacity conservation.

- Transmission of "Maydays" and "Emergency Traffic" receives highest priority.
- Whenever possible, transmission on the radio should be limited to command officers only.
- Formation of self-contained task forces, based on alarm levels, moved-up from staging, offer the greatest opportunity for task assignment and accomplishment, with minimal radio transmissions.
- Face-to-face communication with sector officers, after assignment from staging, provides the greatest prospect for member safety and operational objective achievement, without the use of radio narration typical at routine incidents. In this mode, the radio becomes a receiver of critical information, only broadcast upon for immediate, life safety issues.
- During such times of peak system loading, it will be necessary to suspend or significantly abbreviate the fire department SOP Section 303.XII.A.7 (It states: *When Incident Commanders issue assignments face-to-face, those assignments shall also be announced over the radio to insure that everyone at the incident is aware.*)
- Wherever practical, staging and sector officers will issue verbal, standing orders to be followed, until objective accomplishment, or until further notice. This will reduce the tendency of units to use airtime for task-related information, distracting to the overall operational picture.
- At some point in all mass casualty incidents, it becomes impractical to make individual requests for ambulance responses, to specific victim locations. Whenever possible, low priority patients should be directed or assisted to a triage area, instead of requesting ambulances over the air to specific locations.
- Within the limits of existing policy, patient reports to the hospital, broadcast on the radio system, should be appropriately abbreviated and standing orders implemented wherever practical.

A similar policy is being proposed for local police department adoption, as well.

The main implementation challenge will be to get people to reverse their habits that have been developed and reinforced over years of day-to-day use of the system, and to apply new procedures for rare occurrences. This will be accomplished through training and practice at exercises.

Full implementation across all disciplines and jurisdictions will need to go hand in hand with NIMS implementation. A centerpiece of the new procedure involves sectorizing the incident into manageable pieces, with command officers assigned to task and/or geographical locations. These commanders can assume a lot of line-of-sight and face-to-face communication with people in the task groups, thus eliminating much of the radio traffic at a critical incident. While the fire service has allowed sufficient time for incident command system principles to take hold, law enforcement and other agencies have considerable work ahead in transitioning from NIMS training to NIMS implementation. The *Unified Command* concept within NIMS is optimal when commanders from each agency are present together, at the same incident command post. While the separate command post concept is the practice in many locales, it probably has more to do with avoiding the "who's in charge?" issue than it does with any practical advantage. Unified Command is much more difficult when communications paths must be relied upon, instead of the optimal communications method: face-to-face.

3. Proof of Concept

A training exercise is scheduled for 2006, where a multi-jurisdictional response will be made to a simulated terror act at a school building. This will be the first opportunity to evaluate the effectiveness of this new procedure. While planners are intent upon the elements of the exercise itself, a case has been made for the need to focus on communications limitations and to utilize better sector control within NIMS.

B. GOVERNANCE

The drive for greater interoperability of radio communications has triggered more inter-agency policy development on how such assets should be utilized. There remains a need for greater control and governance over the use of interoperability equipment. While many jurisdictions have some history forming an alliance with a neighboring jurisdiction, it's rare to see all neighboring jurisdictions participating equally, and to see cross-

jurisdictional policies (police/fire, local/county/state/federal, etc.). With the hardware now making it possible to form ad hoc communications networks, it will be critical to get everyone involved to agree to common boundaries of utilization.

1. Radio

The patching equipment being provided through homeland security grants holds the potential for inadvertent impedance of emergency scene communications, by those not fully acclimated with the proper use of such equipment, and/or an appreciation of radio system architecture and the impact a single action may have on the network, as a whole.

2. Data

Interoperability initiatives have included more integration between the information systems used by public safety agencies. Most first responders receive information for responses through dispatchers using computer systems, commonly referred to as C.A.D. (Computer Aided Dispatch). From the moment a 911 call is received from the public, timestamps and address information is gathered within the computer system and pertinent information keyed-in by dispatch personnel. This forms an official record of the event and serves to instantaneously inform field responders of pertinent information, most often through in-vehicle computers and pagers.

Another form of incident-specific data is that which is generated in the Emergency Operations Center (E.O.C.) environment. Incident management software captures key situational awareness components and would be of obvious benefit in incidents impacting entire regions.

3. Process

The advantage of being able to share such incident data between jurisdictions is obvious, and does constitute the wider umbrella of "interoperability," beyond just radio voice communications. The caveat to be pondered, before jumping at such initiatives is the potential impact on individual system stability, network security, and command and control of those able to access information, and therefore able to act independently on self-initiated (and perhaps ill-advised) actions.

Planning and diplomatic process needs to be instigated at the earliest sign of joint-venture in the interoperability realm, since it takes time for relationships to build, trust to

be established, and formalized, written procedures agreed upon, drawn, signed, and implemented. It is one thing to be on a cordial footing at social events and occasional minor incidents, yet quite another to commit to print a collectively agreed upon set of operational policies involving how communications assets will be deployed, mixed, used, and controlled.

4. Standardized Nomenclature

Interoperability initiatives are sure to bring additional focus to the issue of agency-specific codes used over radio systems. While some departments have phased-out their use in recent years, others still cling to radio codes as an ingrained operating practice and custom. Claims of confidentiality value are quickly debunked since casual listeners can easily decode their meaning after monitoring the context in which a given code is used, over a period of time. This ironically gives the hobbyist scanner buff an edge over a potential first responder from another agency. First responders generally don't have the means or inclination to listen over an extended period and build such knowledge.

The International Association of Chiefs of Police recently addressed the Department of Homeland Security's posture that 10-codes used over radio systems should be eliminated in the NIMS process, since 10-codes can confuse matters when separate agencies mix operations at the same event, especially if interoperability equipment is used to patch the radios of several agencies together. There is no national standard for such codes, leading to different meanings for the same code across jurisdictions, leading to the potential for critical errors in times of crisis communications. At the recent International Police Chiefs' meeting, DHS Secretary Michael Chertoff yielded to the hue and cry of the membership to leave everything alone. This demonstrates further evidence that we have a major, "uphill battle" regarding any major changes to customs and traditional operating policies, even when the compelling need to overturn an existing practice is evident.[73]

73 *Police Chief Magazine*, "Police 10-Codes," October 2005. "Homeland Security Secretary Michael Chertoff announced during his remarks at the 112th Annual Conference of International Association of Chiefs of Police in Miami Beach, Florida, on September 27, 2005, that the abolition of the police 10-codes will not be necessary for NIMS compliance." Secretary Chertoff stated, "Under the implementation of the National Incident Management System there has been discussion of requiring the elimination of the 10-code in every day law enforcement communications. However, there was a strong response from the law enforcement community against this proposal, and we listened to your concerns."

C. PRACTITIONER SIMULATOR TRAINING

First responder agencies are para-militaristic in nature, given to operational expectations being delineated within standard operating procedures (SOPs). This reality presents both a challenge and an opportunity, since a mechanism is in place to rapidly and formally institute a procedural change. The conundrum emerges, however, in translating the SOP to actionable, easy to remember and effective procedural changes that will produce modified behavior, under stressful conditions. All first responder agencies have some form of written rules or policies, some more detailed and aggressively enacted than others. So half the battle is getting the new policy written—the remaining and formidable challenge is in getting people to actually use it when appropriate.

1. Recruits

1. Most new first responders receive training in some form of academy format. Curricula should be devised to assure an intermediate level of understanding and appreciation for radio system design, limitations, and proper utilization. Cellular telephone analogies will be helpful, especially for the generation starting to populate first responder agencies.
2. In addition, recruits should be trained in crisis communications, in the event it becomes necessary to reduce the number of transmissions made, in the interest of maintaining the system's remaining capacity for prioritized messages.
3. Alternate communications methods and NIMS principles should be presented as viable alternatives to word-for-word radio reliance.

2. Continuing Education

1. First-responders should receive in-service training on both key concepts and refreshers on existing system considerations, and any time new features or radio procedures are implemented.
2. Careful design of the curriculum is necessary to overcome the natural tendency of first responders to overestimate their existing skill level and to underestimate the need for beyond-basics skills, other than those used in daily practice.

A considerable opportunity exists for future development in the area of simulator training in communications, for first responders. Modeled after the aforementioned U.S. Navy TADMUS example, people expect to "train as they fight and fight as they train." The sophistication level of training must be elevated to the expectation and orientation of

those being trained, especially considering the latest generation of first responders raised on video games and multi-sensory entertainment and education.

We are challenged as a community of first responders to develop a new generation of training aids to improve our ability to maximize communications while running a disaster operation.

3. On-site

Hands-on, action-oriented people need training aids to match their style of doing business. Current computer technology, computer games, and enhanced hardware able to recreate a "virtual reality," presents opportunity for a needed sense of "been there, done that," for first responders, since they will only face truly cataclysmic events perhaps once in a career.

A simple example would be one which is encountered repeatedly in the radio transmissions for the incident studied: Calling for an ambulance to a specific location, for a single patient, when multiple patients are awaiting help and communications volumes are on the brink of radio system collapse.

Imagine the possibility of immersing a first responder in a virtual environment in which "people approach" on a large plasma display, as they stagger away from a realistic disaster scene, and ask for help with a cut finger. The "right" answer advocated by this thesis is to direct the "walking wounded" to triage and treatment locations and not reach for a radio. Those who choose the common and intuitive reflexive action of transmitting on the radio (i.e., on top of other simulated transmissions) would receive a prompt to select a better alternative. This same format could be used to practice radio reports of situational updates, with an emphasis on brevity, voice control, and maximized syntax.

4. Web-based

Modified versions of such a simulator environment could be recreated entirely in web-based education delivery format, allowing for self-paced instruction, and time-transparent training. Features offered by web-based, asynchronous training are important to first responders who need to access training that conforms to their irregular duty hours. It's also easy to envision an expanded format of web-based training, marrying the on-site and web-based deployments into a system of components interconnected to web-enabled

equipment, so the full experience of sight and sound can be accurately recreated beyond that which is possible on a single computer screen.

Building on the experience many new recruits have with video games and the success the U.S. Army has had in recruiting new soldiers with their video games, it's possible to envision the title of "high performing team member" bestowed upon those who progress into advanced levels of disaster-scene crisis communications "games."[74]

D. NEW SCENE COMMAND PARADIGMS

Recognizing the intensive communications needs present for efficient emergency scene success, we should strive to find new and better ways to provide a support system for first responders at the scene. New technology holds the promise of better emergency scene communications support, but it will require examination of how personnel are deployed and operate during an emergency. Over the last two decades, some large first responder departments have begun to transition to a fixed base of command operations at large emergencies, requiring the transition of command personnel from literally standing in the street, to vehicle or building-based command posts. Such facilities provide a greater array of communications support, beyond that which can be dependably delivered over handheld, portable equipment. It admittedly takes time and personnel resources to deploy such assets, so we will always have the need to start operations with more limited capability, but the eventual deployment of enhanced capabilities will be of assistance in what typically becomes an extended operation.

1. Data Displays

Given that limitations exist regarding the delivery of voice communications at intense incidents, a potent possibility resides in providing data to operational commanders. Because of the way data is transmitted over communications systems, more data can be delivered (within the same amount of airtime) than a commensurate amount of voice communications. Using more data transfer, as an alternate to some of the voice information, reserves the most intuitive and valuable form—voice—for the higher priority messages.

74 CBS News, "Army Recruits Video Gamers," March 30, 2004. http://www.cbsnews.com/stories/2004/03/30/eveningnews/main609489.shtml. (Accessed on November 22, 2005).

Appropriate cautions regarding the need for human factors engineering to produce supportive information displays, and user-centered design to avoid information overload, are necessary to guard against overly optimistic expectations. When data is displayed in intuitive fashion, it will do a better job of supporting decision makers operating in stressful environments. Data needs to be displayed so it is readily deciphered without cumbersome interpretation or manual calculations necessary.75 Specifically designated resources personnel, completely familiar with advanced features of complex communications equipment, are key to successful deployment. It is unrealistic to expect the information management function to be fully maximized if it is considered to be an adjunct responsibility of a single incident commander, already overwhelmed with sensory input at the scene of cataclysmic events.

Borrowing from the U.S. Navy's Combat Information Center design, public safety vehicles should be ergonomically configured with communications facilitation in mind. The way the data is displayed on the screen is a key factor in the usefulness of the information and the ability of the operator to use it to maximum effect.76

75 Susan G. Hutchins, Research Associate Professor, interview with author, Naval Postgraduate School, July 22, 2005. "A key factor in the Vincennes incident was that altitude—in terms of whether the aircraft as ascending or descending—was not displayed. Operators had to calculate altitude by comparing current parameters with past parameters to determine whether the aircraft was ascending or descending."

76 Ibid.

Figure 3. U.S. Navy's Combat Information Center (From U.S. Naval Research Lab, Advanced Information Technology Branch, Virtual Combat Information Center)

Graphic Rendering of a U.S. Navy Combat Information Center, provides a sample of the work done to optimize the human-technology interface.

As command post vehicles and Emergency Operations Center (EOC) equipment are purchased with homeland security grant money, public safety agencies are well-advised to apply principles of human design engineering. Recognition of the vast amounts of information available to responders, and the need to display the information in a useful format will require careful design, considering the tendency of people to become overwhelmed with too much information.

2. Cameras in Public Places

It is reasonable to assume that the number of cameras placed in public and semi-public places (hotels, shopping malls, office buildings, schools, etc.) will continue to grow in the upcoming years. The technology to access such information will also allow viewing from remote locations, ideally suited for emergency scene operations. In the "one picture is worth a thousand words" vein, the ability to see the incident scene will greatly reduce the necessity of building situational awareness as a mosaic—one word at a

time. The challenge will be to display and analyze what is seen in a useful manner, while avoiding the pitfalls of information and sensory overload.

3. Sector Vulnerability

A final word is in order about the future of communications for emergency scene personnel. There is great temptation—and the vendor-driven market is poised to capitalize on the government money ready to be spent—to merge public safety communications with the communications systems used by the general public. On one hand, research and development is driven by the wider market and the mass production factors can provide cost benefits. In essence, the personal communications market for teenagers and young adult consumers is likely to drive the relatively smaller public safety telecommunications products development process. However, a number of demonstration projects are starting to lead to deployment of public safety communications systems over open architecture systems, often based on internet connections or other local wireless systems vulnerable to outside overload and attack.

Up until this point in public safety communications evolution, we have enjoyed the benefit of distinct and isolated systems, invulnerable to outside influences. Since so many public safety personnel have started to rely on cell phones for primary and adjunct support of their missions, they have developed confidence in their stability and utility, only to be surprised and disappointed when they fail during times of intense public use. Some systems claim to provide prioritized service for first responder applications, but close scrutiny often reveals poor security protocols, lack of back-up power provisions at transmitter sites, software vulnerabilities, and a system architecture which still requires public safety users to compete with the general public for a finite set of radio channels and/or interface to the switched public telephone network.

Quantum improvements in personal communications will certainly produce valuable applications for public safety personnel, especially in the areas of personal communications devices able to deliver text, voice, and video, but we must be mindful of the sector vulnerabilities present in the general public communications infrastructure. While we may be tempted to adopt the same devices used by the general public, especially if the features are more useful than what is available on our closed-network equipment, it is wise to remain mindful that the public infrastructure is vulnerable to

inadvertent or intentional interruption, at the hands of others. The nature of wireless and internet interconnectedness allows for an enemy thousands of miles away to exploit systems, with no personal risk and no proximity to the target. Much like the reliance field personnel develop on daily use of their portable radios, we too are becoming complacent in our assumptions about the stability of the internet, despite the multiple, known vulnerabilities in the way it is configured.

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VI. CONCLUSIONS DRAWN AND RECOMMENDATIONS

The present policy on radio usage during disaster operations by police and fire agencies is generally mute regarding any procedural changes from that which is applied in routine utilization of the radio systems on a daily basis. Nationwide, numerous reports have identified a problem with radio communications at the scene of disasters, yet the assumption has incorrectly been that the problem is largely a technical one: Once disparate radios are connected, communications will be facilitated. This is a flawed assumption since radio spectrum is a limited commodity—once it's full, it's full. Policies and practices need to be reexamined, from a behavioral/procedural perspective, to optimize the limited channel space we have, until new technologies can be developed and deployed to expand the capacity for more information to flow. Even if more information is available, we have discovered there are limitations to human utilization of large amounts of information in times of crisis.

Many involved in the first responder community shy away from technical discussions about radio system architecture. We are comfortable using cellular telephones, for instance, but most would be hard-pressed to give a technically sophisticated description of how cellular telephone systems work. Similarly, this thesis takes a users' perspective in devising reasonable strategies for the improvement of emergency scene radio communications, even for those with only a superficial knowledge of radio system theory.

A. DETAILS OF THE CONCERN

Homeland security efforts have been heavily focused upon interoperable radio communications for local emergency responders. Recent homeland security dictates have listed interoperability as the number one focus for those seeking grant funding. Post-disaster analyses, including the 9/11 Commission Report, have described a common frustration of ineffective communications at the scene of emergencies.[77] Assumptions made by the misinformed general public, as well as by public-sector policy makers, have

77 National Commission on Terrorist Attacks, 2004.

led to a misguided solution strategy. Solution strategies currently being pursued may actually make matters worse, instead of better (via overloading systems by patching too many users together), despite hundreds of millions of public dollars awarded through grant funding to *improve* communications.

With delivery of interoperable radio equipment to many public safety agencies nationwide, first responders are now technically able to link communications from a multitude of response units at the scene of a disaster. Emergency scene communications dynamics are inherently complex because many diverse organizations become involved. Patching equipment is far from a global, turn-key solution, and the potential to produce more harm than good, with such equipment, is present.

The assumption to this point has been that the first responder communications issue is a technical one, i.e. separate radio platforms, or coverage issues leading to ineffective emergency communications. While this is often true, to some extent, this thesis argues that the majority of the future focus should be on procedural issues, considering the realities of how people perform during times of stress, rather than technically focused on how to patch radios together. Reviews of public safety radio transmissions during disasters, including the terrorist attacks of September 11, 2001, reveal a mélange of words and excited phrases that are often conflicting, disconnected, or superfluous.

In one such recording from 9/11, a police officer in New York City can be heard requesting an ambulance to a street corner for persons with relatively minor injuries ("walking wounded"). This would be a perfectly normal and reasonable request on nearly any other day when observing someone needing an ambulance—reach for the microphone and request an ambulance. Not to minimize the huge challenge facing emergency responders that day, and similar situations do occur in most large disasters—but that 30 seconds of radio time could have been put to better advantage, considering that two of the tallest buildings in the world were about to fall down, and thousands of people were in peril.

While the events of 9/11 are viewed through our hindsight of what did actually occur, (and our overall awareness of verified factors not apparent to many at the scene that day), there is a need for responders to future cataclysmic events to monitor quantifiable triggers, such as:

- number of victims,
- area involved,
- types of attack methods used,

which should compel (via written procedure, training, and practice) the use of alternate communications tactics and contingencies. The "walking wounded," for instance should be encouraged to keep walking or redirected to a central treatment area, and radios should be used for priority messages only. Such strategic use of radio systems during disasters has not generally been part of first responder orientation and training to this point.

An illustration of our lack of attention to individual training and procedures for radio use for first responders can be made by considering the typical subject areas in the training program for police officers. While use of the portable radio, which will be used many times every day, has been largely self-taught, areas like firearm use and evidence handling usually comprise several hours initially and are given periodic refresher training. Conversely, most field personnel only know how to use a fraction of the features on a typical portable public safety radio. When it comes to the portable radio, it's unlikely that the officer knows much more than how to change a few channels and what button to use to push-to-talk. (In contrast, in 1995, when U.S. Air Force Captain Scott O'Grady was shot down over Bosnia, he used survival training he had received, including expert use of his portable radio, to conserve battery life for six days and to coordinate his own rescue over the radio. At present training levels, it's hard to imagine our first responders doing the same thing.)

The 9/11 Commission Report goes into great detail about the failings of the radio systems of the various agencies responding to the terrorist attacks.[78] Transcripts and recordings reveal that there was almost constant chatter, albeit choppy and often unintelligible. Setting aside the technical issues, of which there were many, a lot of

78 National Commission on Terrorist Attacks, 2004.

people still talked on the radio; so a lot was being *said*, but *communication* was weak. The emotion in their voices is obvious, as they give witness to a horrific scene, (shades of the 1937 *Hindenburg* crash recording, "Oh, the humanity!" which interestingly was not being broadcast live, and killed a comparatively few 35 people, yet the experienced radio announcer was choked with emotion). We have to anticipate that even hardened veterans will be at an operational deficit in their ability to control their emotions, when faced with the most intense of emergency situations.

It is relatively easy to make any radio talk to another through patching equipment. Equipment being deployed now through homeland security grants will make patching equipment much more available than ever before. But if each user of the system intends to use their radio in the same manner as they normally would on partitioned systems, it will be far more difficult to manage the large increase in the amount of radio traffic that will be squeezed onto a common platform. The result is likely to be even heavier radio congestion, and less, rather than more, *effective* communication.

Emergency responders develop habits during day-to-day, routine operations. In facing typical workday situations, they use the radio to get critical information, to request a back-up, redirect to correct locations, etc. Field personnel develop a level of familiarity and a comfort zone with procedures they have adopted over time. These habits become the default operating procedures during times of crisis. This phenomenon is attributable to human nature where we tend to revert to patterned behaviors during times of stress. This is the logic behind practice exercises before an emergency, much like the fire drills we all experienced as school children. In short, unless people have consciously considered an alternate behavior, *before* facing a crisis, we tend to go with what is familiar.

Due to the criticality of communications during crisis events, it is imperative to devote resources to developing and implementing new procedures for responders during emergencies. This serves to increase awareness of the need for people to communicate differently in overload situations, instead of the typical practices of loading more and more radio traffic into common radio space, until communications turns are not accomplished, and responder safety and effectiveness is impaired.

By their very definition, high risk/low frequency events don't occur very often. It takes a tremendous amount of interest, discipline, and insightful appreciation for the need, to prepare for something that only happens perhaps a handful of times in one's career. This is a classic conundrum: how much time should we spend on something that may never happen? Post-9/11 management of first responders has pushed us into unknown territory, in this regard. Deciding on a prudent approach, appropriate for each locality, is one of the most pressing strategic issues of the next few years.

B. STRATEGIC CONSIDERATIONS FOR IMPROVED OPERATIONS

Communications are at their most critical point during the response phase of an emergency. During the response phase, life safety matters are typically at their most acute state, with people waiting for rescue and treatment, coupled with a focus on intervention to the perpetrators, damage assessment, and general situational status reporting. These stressful missions tend to introduce the most emotionally charged communications during the first hour of the incident, even though the recovery phase may stretch for weeks and months.

Anyone around emergency services for a few years will recognize the role adrenaline and other stress-related reactions play in altering voice pitch and inflection when someone is talking on the radio during a serious incident. This is the reason emergency personnel can leave their radios on all day, only half-listening to what is being said, but listeners immediately refocus their attention when someone is reporting something serious. As anyone who has listened to the aforementioned recording of a reporter describing the crash of the Hindenburg ("oh, the humanity!") can attest, stress causes the human voice to take on a very unique quality, and the speaker can literally succumb to a state of "speechlessness." Recognition of this reality will allow us to scale-back our expectations of effective radio communications at intensive emergency scenes, seek alternative communications methods, and target our prioritization efforts, for maximum value, and improve operations.

Given the infrequency of disasters and the resultant lack of first-hand experience of individual participants, it will be important to capitalize on analogous lessons learned by the U.S. military, as well as first responder training and near-disaster situations. After-action reviews offer great potential to gain attention, and affirmation regarding the need to improve communication procedures, before responders go back to their daily routines. In the hours and days following a major incident, the opportunity to gather information and identify causal factors is at its greatest, while the incident is still fresh in everyone's minds and the momentum for change will be present. Although less precise and scientific, comments about communications garnered during after-action reviews provide a barometer of the degree of success regarding programs to implement improvements.

The idea to keep in mind is that people revert to practiced behaviors when confronted with stressful situations. It is critical that the tendency of first responders to talk too much during an emergency be corrected. Spending more time listening to what is being said and saving precious radio spectrum for prioritizing life safety traffic only is essential—and represents a new policy that needs to be taught and practiced. This will require specific guidelines, training, practice and application by fire crews, patrol officers, public safety communications personnel, and their respective supervisors.

The term *Crisis Communications Plan* has its widest usage in the private sector, referring to situations where a need exists to manage media relations for corporate viability, such as in product tampering situations, or corporate take-overs. In our context, the term applies to a situation where large numbers of first responders are operating at the scene of one or more emergencies, and the need to optimize scarce communications assets is most critical.

The *Crisis Communications Plan* is advocated whenever command is established at the scene of an emergency where a large number of responders are present, and radio communications are beginning to degrade. Its features include:

- Encourage face-to-face communication within NIMS sectors
- Designate staging areas (where responders are directed to muster before deployment in the hazard zone) are to be designated by command, where units will report and return silently to staging officers at those locations, without radio usage

- Establish a dedicated communications path limited exclusively to command situation status reports and requests of additional resources from/to dispatch
- Command and dispatch will coordinate with one another to broadcast situational status reports at regular intervals
- Activate a periodic, soft beeping signal to be played over the radio channel, indicating to field units that life safety messages are to be prioritized, and they are to use other communications means for minor matters.

C. CONCLUSION

In just a few short years, communications have risen to the very top of homeland security response concerns. While communications were a frequently cited concern in a number of after-action reports prior to 9/11, considerable momentum advocating change has developed since the release of the 9/11 Commission Report.[79]

Reminiscent of the frenetic drive to fix computers prior to Y2K, the last few years have been marked by a frenzy of meetings, focus groups, studies, vendor-driven solutions and "last-minute-deadline" grant purchases aimed at improving radio interoperability. Even the phrase itself, "interoperability," was not in common usage just four years ago. Now the mere mention of the word will fill a conference room and assure standing-room-only at seminars. The well intentioned, but misguided, assumption by those driving the process has been that the main challenge is technical; make all the radios at an incident talk to one another, and improved "communication" will be the instant result. This ignores the reality of limited radio frequencies ("air time") and the common occurrence of single agencies overwhelming their own radio channels. Simple logic will make it possible to anticipate the result if two or more agencies take their "beyond capacity" radio conversations from separate systems and tie them all together.

With over one billion dollars allocated to homeland security grants, (including hundreds of thousands of dollars earmarked nationwide for interoperability purchases), and new equipment soon to arrive all around the country, it is imperative that we understand the negative impact likely to result if we do not change *how* we use radio resources. We have some choices to make regarding how to administer interoperability.

79 National Commission on Terrorist Attacks, 2004.

The greatest need is to modify procedures and the behavior they are designed to produce, both in daily use, as well as during disaster operations. We need to retrain field personnel in optimal radio operation procedures aimed at prioritizing radio transmissions for life-safety, overall situational awareness status and broad command and control.

This sounds easy, even self-evident, but it is very difficult for people faced with a crisis to do anything other than what they have practiced in routine, daily operations. The recommendations made represent a realistic set of alternatives for addressing the need to see the communications issue as a complex set of behaviors. These recommendations include engineering communications assets to fit the way first responders will tend to react in emergency situations and introducing the new technologies with commensurate, relevant procedural changes.

APPENDIX

Transcript of North Texas area fire departments training exercise held October 17, 2005, with analysis and comments added by the thesis author.

E=Engine T=Truck M=Med. Unit (Ambulance)

PSC=Public Safety Communications

			Drill on October 17, 2005 - starts at 7:34:52 pm-ends 8:36:02 pm
Turn #	***Time of Day***	***Reviewer's Comment***	***Text of the Message***
1	7:34:52 PM		Batt.177 En route
2		*Exclamatory!*	All Engines going to the floor investigation - STOP!
3	7:35:18 PM		E419 you can go
4			Excuse me E114 you can go
5	7:35:39 PM		E114 you can proceed to the call
6			M494 would you tell E114 they can proceed to the call and its on channel 13
7	7:36:42 PM	*Unacknowledged*	E3 hold up
8	7:37:00 PM	*Repeat*	E3 hold up
9			Richardson E3 Received
10		*Unacknowledged*	M494 you can go
11		*Repeat*	M494 you can go
12	7:39:11 PM		E3 you can go
13			E3 Received
14			E114 on scene we have a large 3 story structure; fire showing from the 3rd floor; lets go ahead and have a 2nd alarm on this; level 2 staging we are going to enter the building with a line and initiated fire attack, next one in lay us a line, and also we're going to need a second line in coming behind us.
15			PSC copy
16			E114 on scene large 3 story; fire from the 3rd floor; request 2nd alarm; level 2 stage
17			T174 you can go
18	7:40:30 PM		From John
19			This is staging
20		*Radio Compatibility Issue; Resolved*	This is John Boyd go ahead and send one of the Batt. Chief now; go ahead and send him up we have a radio issue; nobody's radio works on the channel so we'll get them up here and get things rolling right
21			B177 you can go
22			Richardson E3 is on the scene will be laying along the attack engine
23			PSC copy Richardson E3 on the scene
24	7:41:19 PM		E602 is En route
25			T174 is on scene
26			Received

27	7:41:52 PM		E172 En route
28			Received E172
29			B491 you can go
30			E179 En route
31			Received E179 En route
32	7:42:33 PM	*Questionable*	E114 to incoming- we are going to need forced entry into the front door of the building.
33	7:43:00 PM	*Redundant*	B177 out looks like 3 stories wood construction heavy fire 3rd floor B177 gonna be Command
34			E602 you can go
35			E602-going
36			Received 602 En route
37			PSC copy B177 is Command 3 story wood construction heavy fire from the 3rd floor
38			B177 to E114
39	7:43:58 PM		PSC to Capt. Stone please call public safety extension 7952; PSC at 7952
40			Command to E114
41			T174 to Command
42			Command to T174 go ahead
43			Command to T174; Dan what I want you to do is go ahead and set your aerial ladder... We're going to need ventilation on that vertical ventilation on that top floor there; once you get that set up let's make sure we got a fan in the stairwell so we want to keep that stair way clear as well, you're going to be ventilation group.
44			T174 to Command
45		*Repeat*	Command to T174 did you receive my last message
46			I heard the end of it, you would like us to set up our fan and ventilate the stairwell is that correct
47		*Repeat*	That's affirmative, I want you to go ahead and set your aerial ladder vertically ventilate and make sure that stairwell is clear make sure that got a fan that stairwell as soon as possible
48			Received, we will set the fan first and we will extend our aerial ladder vertical ventilation
49			E472 hold up; Prosper 1 hold up
50			E472 Receive
51			Prosper 1 Receive
52	7:45:58 PM		Command to E114
53			E114 go ahead
54			What's your location right now
55			We're at the door along the fire at this time we're waiting for our crew for forcible entry ; we do have a preconnect on the ground at the front door
56			Received, just based on looking at the outside of the structure where you're standing I don't know that you'll be able to get to the fire from where you are, I'm probably going to send a crew around the back side to see if they can go up the stairs from the back side and get to the fire
57		*Questionable*	Received, we also did another looking around on the front
58			E472 go ahead
59			E472 on the way
60			Command to Richardson E3

61		*Confused*	E602 to Command were you calling us?
62			Command to E602
63			Command this is E602 go ahead with the traffic
64			I want you to go to the, we are going to call the west side of the building the A side I want you to go to the C side of the building, you'll probably going to need a high-rise pack in the back, see if you can find a standpipe, gain entry and gain access to the fire from the C side of the building
65			OK 10-4 E602 is going to the C side of the building to make a rear entry with high rise pack
66			Richardson E3 to Command we are available for assignment, we have laid a supply line to Carrollton engine
67			Prosper E1 go ahead
68			Prosper E1 receive
69	7:48:39 PM	*Unacknowledged*	E472 to Command
70	7:48:55 PM		E472 to Command
71			Command go ahead E472
72			We're en route to your location ready for assignment
73			That's E472 I want you to pull around to the C side of the building, I want you to hook up to the standpipe back there and support the crew that's going up to the fire floor from the C side of the building
74			E472 received, we'll be, we'll be supplying the standpipe for the crew to go up the stairwell
75			Received you'll be E602 going on that side
76		*Unacknowledged*	E114 to Command
77			E602
78			We have our doors forced open E114 is going in with a 1-3/4" hose line
79			E178, M179 go ahead
80			Richardson E3 to Command
81			Command go ahead Richardson E3
82			E3 has laid a supply line to the Carrollton engine we are ready for reassignment
83			Received Richardson E3, I want you to bring a positive pressure ventilation fan to the C side of the structure, we're going to be using the stairwell back here we want that fan set up in the stairwell
84			E112 to Command we're ready for assignment
85			Receive hang on E112
86			…(garbled)…….
87			B491 go ahead
88			E472 to Command
89			Command go ahead E472
90		*Questionable*	We're parked here behind E112 and we can't get through they need to move up a little bit
91		*Repeat*	Repeat, repeat your last message
92			10-4 we receive the message E112 was parked in front of us, we could not get through he has now moved at this time so we're moving to our (garbled)
93		*Unacknowledged*	Received, Command to Richardson E3
94	7:51:50 PM		E114 to Command
95			Command go ahead

96			PSC to Command 10 minutes on scene
97			Command received 10 minutes on scene
98			T174 to Command
99			Command go ahead T174
100			We have forced 1 door we have the fan set in the door they are advancing the hose line we'd like to force entry of another couple of these doors if that's alright
101			Received Dan I want y'all to go to the roof and open the roof up, open the area over the stairwell and make sure we got good ventilation vertical ventilation on the roof
102			Received we'll be sending a crew through the roof for vertical ventilation
103			Command to Allen Batt. Chief
104			B491 on the scene
105			Received B491
106			… (Covered) to Allen Batt. Chief
107	7:53:37 PM		Richardson E3 to Command are you ready for PPV in the C side rear entrance
108			That's affirmative
109			E3 received it's done
110			Richardson E3 to …
111		*Unacknowledged*	Come in Richardson E3
112			Richardson E3 to Command
113		*Repeat*	Go ahead Richardson E3
114			Richardson E3 to Command we have found that the alarm panel in the Charlie Delta corner, the alarm panel is showing smoke alarm activated on floors 3 and 4 the sprinklers are out due to valve trouble
115			Received, the sprinklers are out due to valve trouble
116		*Unacknowledged*	B491 to Command
117		*Unacknowledged*	Command to E173
118			Command to Richardson E3
119	7:55:20 PM	*Unacknowledged*	Prosper E1 to Command
120			Richardson E3 to Command
121			Command go ahead
122			Be advised we have found the blue print and have the location of the pump room if you wanted to check that out
123			Received I think I got Engine Richardson E3 in the pump room right now, what's your location
124			Be advised this is Richardson E3 and we are in the alarm room, not the pump room however. We have located the pump room and can make it to that location. Also be advised that the alarm is going off on the 5th floor at this time
125			Received we have an alarm on the 5th floor at this time
126			That's affirmative, would you like us to check out that pump
127			Yes, go ahead and check the pump out
128		*Unacknowledged*	E114 to Command
129		*Questionable*	M179 on scene
130			114 to Command
131			Command go ahead

132			E114 to Command and E114 driver, we need to charge the line, we're on the 3rd floor we're going to make entry as soon as our line is charged
133			Command received what's your visibility in there, how's your ventilation
134			We temporarily cracked-open doors—moderate amount of smoke
135			Received
136		*Unacknowledged*	E114—need an officer are you advising to charge the line?
137			Command E472
138			E472 go ahead
139			When you get hooked to the standpipe back here go ahead and take your crew; let's go up to the 3rd floor and work our way up checking the floors from this side over here
140			E472 go up to the 3rd floor, check for survivors
141		*Repeat*	E114 you want water
142		*Unacknowledged*	Richardson E3 to Command
143	7:58:17 PM	*Repeat*	Richardson E3 to Command
144			Command go ahead
145			Richardson E3 Command be advised we found open drain valves in the water system we have closed them at this time. We ought to have some pressure
146			Received… thank you
147			Command to E114
148			E114 go ahead
149			OK you're going to be Division 3
150			Affirmative we're Division 3. We have (garbled) with us additionally we're going to need our hose charged
151			602 to Command we need the standpipe for this building charged, we need the standpipe charged from the outside
152			We're hooked-up to the standpipe
153		*Repeat*	Command repeat that last message
154		*Unacknowledged*	E179 to Command, we're in the area, where is staging set up
155		*Unacknowledged*	E472 to Command
156			Command to E179 don't stage….go ahead and come on down
157		*Unacknowledged*	E472 to Command
158	8:00:24 PM	*Unacknowledged*	E472 to Command
159			Command go ahead 473
160		*Repeat*	E472 to Command
161			Command go
162			we're ready to support the standpipe on the C side, if you're ready than we'll charge it
163			Go ahead and charge the standpipe now and when you get your crew ready go ahead and take them inside and meet up with Division 3
164		*Unacknowledged*	10-4 we're charging the standpipe, we're meeting up with Division 3 up on the 3rd floor. Is that going to be on the C side?
165		*Unacknowledged*	E114 to Command
166			Command to E112
167			E112 go ahead
168			Take your crew go inside and meet up with Division 3 they're probably going to need some relief pretty quick

169			Received
170			Is our engine parked in a good spot or do we need to park it out of the way?
171			Where you're parked is fine
172		*Face-to-Face Use?*	E178 take your crew to the C side of the structure I want you to go in and back up E472
173			E178… C side and back up E472
174			E493 to Command
175			Command go ahead 493
176		*Face-to-Face Use?*	I'm sitting here waiting for assignment
177		*Unacknowledged*	...3 to Command
178			Received- stand by
179			E172 is out
180			Received E172
181			PSC to Command 20 minutes on scene
182			Command received 20 minutes here
183			Command to Division 3, are we making progress on the fire
184			Division 3…….
185		*Repeat*	Command to Division 3, I didn't read the last transmission
186			Command to Division 3
187		*Wrong Unit Ans.*	Richardson E3 go ahead
188			This is Division 3, we have … smoke, we can't knock down the fire we're going to need a second line, also we have an alarm that are ringing and E1… will be coming down at this time
189			Received
190			Carrollton E112, Division 3 says they're out of air coming out, go ahead and try to meet them coming out and get a report from them, they're on the A side
191		*Unacknowledged*	E112 Division 3
192			Command to E172
193			E172
194			Jay, can you come to the C side of the structure? I'm going to have you go to the 4th floor and be Division 4
195			Received, report Bravo side, Division 4
196		*Confused*	Charlie side Division 4
197			Received Charlie side, Division 4
198		*Unacknowledged*	Prosper Engine 1, E112 to Division 3
199			Command to Prosper Engine 1
200			Go ahead
201		*Unacknowledged*	Prosper Engine 1 to Command do you have traffic
202	8:06:03 PM	*Unacknowledged*	Prosper Engine 1 to Command do you have traffic
203		*Unacknowledged*	Division A to Command
204		*Repeat*	Command repeat your last message
205		*Unacknowledged*	Division A to Command
206			T174 did not (garbled) ventilation do you want another task for him?
207			Received, we're going to have to have ventilation, have them change the plan on whatever needs to be done to get them ventilation up there
208			Division A received, we'll change the plan

209			Prosper Engine 1 in Command
210			Command go ahead Prosper Engine 1
211			Yes sir did you have traffic for us a moment ago
212		*Alt. Comm.-plus*	Yeah come back to the C side of the structure for face to face with Command, we're sitting on the B/C corner
213			Received meet Command on the B/C corner
214			E179 to Command
215			E179 go ahead
216			E179 and E493 are two companies still at staging
217			Received
218			E179 go ahead and come down to Command, the B/C corner of the building for face to face
219			Received E179 come to the B/C corner to confer with Command
220		*Exclamatory!*	All units hold your traffic, stand by, E602 to Command
221			go ahead E602
222		*Exclamatory!*	We're got, we got fire on the first floor between the… bring the second hose line up here …we've got a lot of heat and smoke
223			Received Command E178
224		*Unacknowledged*	Command
225		*Unacknowledged*	E178
226			Command to 472
227			Command to E472
228	8:09:30 PM		E472 to Command
229			Have you gotten a line up there to back up 472 on the 3rd floor?
230		*Unacknowledged*	602 on the 3rd floor
231		*Unacknowledged*	Division A to Command
232			Division 472 B to A
233			476 go ahead
234			Command wanting to know if you have a line to back up Division 3
235			We're going to need a line up to the 3rd floor (garbled)
236		*Unacknowledged*	E114 to Command
237			Division A to Command
238			Command go ahead
239			T174 we're going to split the four crew up - we're going to have 2 on the 1st floor -cross ventilation and 2 on the 2nd floor cross ventilation
240			Received
241		*Exclamatory!*	E602 to Command
242			E602 go ahead
243			Ok let me know on the status on the second… be advised we got a lot of flames across the ceiling
244		*Repeat*	Repeat your last transmission
245			We're checking for fire extension on the floor above us, we got a lot of fire on the 4th floor
246		*Unacknowledged*	E472 to Command
247			Command to
248		*Unacknowledged*	E3 to Command
249			Command to 602, go ahead and withdraw from that location
250		*Exclamatory!*	E602 copy, E602 going to withdraw ……
251			Division. 3 (garbled)

252		*Unacknowledged*	Command to E172 do not go to the 4th floor
253		*Unacknowledged*	E114 to Command
254			Command to Division 3
255			Division 3, go ahead
256			I want you to go ahead and withdraw from the 3rd floor, withdraw to a safe location, get out from underneath the wood trusses
257		*Unacknowledged*	E472 to Command
258		*Unacknowledged*	E114 to Command
259		*Unacknowledged*	Division. 3 (garbled)
260		*Repeat*	Repeat again
261			PSC to Command 30 minutes on scene
262		*Unacknowledged*	E114 to Command
263	8:14:15 PM		Division. 3 to Command- we have withdrawn to a safe location
264	8:14:34 PM		E602 what's your location
265			E602 withdrawing from the stairwell, going down the 1st
266			Received
267			Division 3 to Command
268			Division 3 Command to Division 3
269		*Repeat*	We are withdrawing to a safe location in the hallway
270			Command to Division 3
271			Division 3 go ahead
272		*Unacknowledged*	I want you to make sure everyone is out of the floor area there into at least the stairwell as relocation and let me know when that has been accomplished
273		*Questionable, Unacknowledged*	E114 to Command we're setting up rehab on the C/B corner of the building
274	8:16:14 PM	*Unacknowledged*	Division 3 to Command
275	8:16:40 PM		Division 3 to Command
276			Command go ahead, having trouble understanding you
277			Division 3 everybody in the stairway
278			Received
279		*Unacknowledged*	T174B to Command
280			Division A to Command
281			Command go ahead
282			We still have heavy fire on the A side with smoke flared back up
283			Received
284			T174B to Command
285			Command go ahead
286			We have fire on the 5th floor when you can get a hose line up here please
287		*Repeat*	Repeat your last transmission
288			We have had heavy smoke - free burning fire, get a hose line
289			What's your location?
290			We're in the 5th floor
291			Received, go ahead and withdraw through the stairwell
292			Received, we will be going to the stairwell
293			E114 to Command
294			Command go ahead

295		*Repeat*	You didn't receive my message earlier we're manning rehab at the C/B sector, also at this time we have a 2 man crew here, E114 is available to be reassign if you need us
296			Receive E114 thank you
297			……to Command
298			E602 to Command
299			Command to E602
300			Our company's out of the building, we're changing air bottles
301			Received
302			Command to all units
303			Withdraw from the structure
304			Command to Division 3 let me know when all of your crew are out of the building, Command to Division 4 let me know when all of your crew is out of the building
305		*Unacknowledged*	T174B to Command
306		*Unacknowledged*	T174B to Command
307			……to Command
308			Standby for emergency traffic
309			Standby for emergency traffic
310			Abandon the building; Abandon the building
311			Standby for a PAR (Personnel Accountability Report), where ever you've exited the building
312			Command to PSC
313			Command go ahead
314			I need you to do the signal for to abandon the building
315			****signal noise*****
316			All units abandon the structure, abandon the structure, abandon the structure
317			Division 4 to Command we have a PAR…
318			Command receive, Division 3 go ahead and let me know which units you have PAR with?
319			E602 is off of 1
320		*Repeat*	Repeat that
321			E602 is off of 1 Engine 1
322			Received E112 do you have PAR?
323			Yes affirmative, we have PAR
324		*Unacknowledged*	Division. 1 to Command
325			E472 do you have PAR?
326			E472 we have PAR
327			E114 do you have PAR?
328			E114 has a PAR
329			M494 do you have PAR?
330			M494 has PAR
331			Richardson E3 do you have PAR?
332			Richardson E3 has PAR
333			T174 do you have PAR?
334			T174 have PAR
335			M179 do you have PAR?
336			M179 has PAR
337			E178 do you have PAR?

338			E178 has PAR
339			E172 do you have PAR?
340			E172 has PAR
341			E493 do you have PAR?
342			Par
343			E179
344			E179 has PAR
345		*Unacknowledged*	Command to T174
346		*Repeat*	Command to T174
347			T174 to Command go ahead
348			Go ahead and set up your aerial master stream for defensive operations on the A/B corner
349			Received, you want us to put water in the 3rd floor A/B corner window?
350			Received
351			Command to E178
352			E178
353			Go ahead and set up for defensive operations on the B/C corner, go ahead and set your aerial master stream for that
354			Received E178 will be setting up master stream on the B/C corner
355	8:24:57 PM		T174 to Command
356			Command go ahead
357			Who would you like us to get water from?
358			Go ahead and get it from the initial attack engine if you need to
359			Received and that is Carrollton 114
360			I believe so, Command to Richardson E3
361			Richardson E3 go ahead
362			If possible go ahead and set up for defensive operations on the A/B corner with your aerial apparatus
363		*Unacknowledged*	E472 to Command
364			PSC to Command 40 minutes on scene
365			Command received 40 minutes on scene
366		*Unacknowledged*	T174 to Command
367			We're going to be detaching the standpipe on the side street, we'll be bring the aerial in and making room for aerial device
368			Command to E472
369			E472 go ahead
370			Go ahead and use your deck gun, defensive operations back there, make sure you're not in the collapse zone
371			10-4 E472 be going to defensive
372			That's affirmative go ahead and use your deck gun there
373			brought back here…
374			Richardson E3 to Command
375			Command go ahead
376		*Unacknowledged*	Richardson E3 to Command be advised our path is blocked by 5" supply hose we are on the A/D corner if you want to set up aerial operations there
377			…. E602 bravo
378		*Repeat*	Repeat traffic
379		*Unacknowledged*	T174 to Command

380			call T174
381			E4….
382			Received we will be going through a fog and we are already applying water in the 3rd floor window
383			Received, Command to Richardson E3 go ahead and use your aerial device where you are
384			E3 received, be advised we are going to need water supply
385			Received
386			E178 A E178
387			E178 go
388			Just pull up behind this engine and we'll take water from them
389			I've been advised by ……this is B/C corner where we're at right here
390		*Unacknowledged*	E472 to Command
391	8:28:55 PM	*Repeat*	E472 to Command
392			Command go ahead
393			We have a monitor master stream C side, 3rd story we have room for an aerial if you pull up here beside us
394			Receive
395	8:29:26 PM		E602 to Command
396			Command go ahead
397			This is E602 we have our 50 ft aerial in position where the water supply, do you want us to enter the same side of the truck?
398			Receive you can hit the B side that will be good
399	8:32:00 PM		E472 to Command
400			Command go ahead
401			We're ready on the C side for the aerial to get them water
402			Receive I don't think we have one to get them over to you right now, thank you
403			We already have 5" line hooked up from E472 to aerial. Did you want…
404			Received ok, thank you
405			PSC to Command 50 minutes on scene
406			Received 50 minutes on scene
407	8:32:55 PM	*Unacknowledged*	E472 to Command
408	8:33:17 PM		E472 to Command
409			Command go ahead
410			Did you want us to send water from 472 to the aerial on the C side
411			That's affirmative
412			10-4 it's on the way
413	8:33:53 PM		Richardson E3 to Command be advised we have aerial ladders set and water flowing onto the 5th floor A/D side
414			Received are you making any progress on the fire?
415			Fire appears to be darkening on the 5th floor
416			Received
417			E472 to Command
418			Command go ahead
419			Fire is darkening on the C side
420			Received thank you
421	8:35:02 PM		E178 to Command
422			Command go ahead

423			E178 is set and operating in master stream
424			Received let me know on your progress
425	8:35:42 PM		E472 to Command
426			Command go ahead E472
427			Is E178 aerial getting sufficient water pumping water?
428			Command all units discontinue the drill the drill is over

Communications Anomaly Analysis Summary

% of Turns	# of Turns	Anomaly Type
11.9%	51	Unacknowledged Message
4.9%	21	Needed to be Repeated
2.6%	11	Confused/Unclear/Questionable Value
1.2%	5	Exclamatory/Excited Message

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